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ABSTRACT

This workbook (first in a series of three) supplements the textbook of the third year Naval Junior Reserve Officers Training Corps (NJROTC) program and is designed for NJROTC students who do not have the reading skills necessary to fully benefit from the regular curriculum materials. The workbook is written at the eighth-grade readability level as determined by a Computer Readability Editing System analysis. In addition to its use in the NJROTC program, the workbook may be useful in several remedial programs such as Academic Remedial Training (ART) and the Verbal Skills Curriculum, both of which are offered at each of the three Recruit Training Commands to recruits deficient in reading or oral English skills. Topics in the workbook include naval history (1920-1945), leadership characteristics, meteorology, astronomy, and introductory electricity. Exercises include vocabulary development, matching, concept application, and extending learning activities. (Author/JN)

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TECHNICAL REPORT 124

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Technical Report 124

WORKBOOK FOR NAVAL SCIENCE 3: AN ILLUSTRATED WORKBOOK FOR THE NJROTC STUDENT

Training Analysis and Evaluation Group

May 1982

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This workbook supplements the textbook of the third year Naval Junior Reserve Officers Training Corps (NJROTC) program. Workbook For Naval Science 3 is the result of a joint effort by the University of Central Florida and the Training Analysis and Evaluation Group (TAEG). The workbook was developed in response to a need for instructional materials suitable for use with students who do not have sufficient reading skills to cope

(continued on reverse)

20. ABSTRACT (continued)

with the regular curriculum material. Workbook for Naval Science 3 is the first workbook in a series of three. Workbooks for the first and second year NJROTC programs will be published in 1983.

INTRODUCTION

The Training Analysis and Evaluation Group (TAEG) was tasked by the Chief of Naval Education and Training[1] to serve as technical monitor and to provide production assistance in the development of supplemental instructional materials for the Naval Junior Reserve Officers Training Corps (NJROTC) program. The tasking for the development of this workbook resulted from the successful use in the NJROTC program of a previous textbook prepared by the TAEG, Improving Your Navy Reading Skills (described in Kincaid and Curry, 1979). The present workbook is the first of a series of three and is designed to supplement Naval Science 3, the primary text of the third year NJROTC program. Workbooks for the first and second year NJROTC programs are currently being developed.

This workbook is designed for NJROTC students who do not have the reading skills necessary to fully benefit from the regular curriculum materials. Students who are reading significantly below their grade in school comprise a large proportion of the students in the 250 NJROTC programs across the country. In order that these students may more fully benefit from the program, it became necessary to develop easily readable materials containing appropriate instructional exercises. The Workbook for Naval Science 3 is written at the 8th grade readability level as determined by a Computer Readability Editing System (CRES) analysis (Kincaid, Aagard, and O'Hara, 1980). The CRES analysis was also helpful in selecting words for the vocabulary exercises contained in the workbook.

The workbook is the result of a joint effort of the University of Central Florida and the TAEG. Stuart E. Omans of the University of Central Florida is the primary author of the workbook. Personnel from the TAEG participated in writing the text, served as reviewers, and provided editing and production services.

Topics included in the Workbook for Naval Science 3 were determined by interviewing several NJROTC instructors, and a majority agreed on the final selection of topics. Topics in the Workbook for Naval Science 3 include naval history 1920-1945, leadership characteristics, meteorology, astronomy, and introductory electricity. Exercises include vocabulary development, matching, concept application, and extending learning activities.

PURPOSE OF THIS REPORT

The purpose of this report is to make available the Workbook for Naval Science 3. In addition to its use in the NJROTC program, the workbook (and the two others being developed) may be useful in several remedial programs, such as Academic Remedial Training (ART) and the Verbal Skills Curriculum. Both of these programs are offered at each of the three Recruit Training Commands to recruits deficient in reading or oral English skills.

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[1] CNET ltr N-53 of 8 Jan 1980

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WORKBOOK FOR NAVAL SCIENCE 3

An Illustrated Workbook for the NJROTC Student

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DEPARTMENT OF THE NAVY • ORLANDO, FLORIDA

MAY 1982

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FOREWORD

The workbook for Naval Science 3 began as a limited project. To be more helpful and complete it grew into its final form including an extended series of illustrations, maps, and, most important, challenging exercises for the student reader. The workbook is intended to supplement Naval Science 3, the official textbook for the third year Naval Junior Reserve Officers Training Corps (NJROTC) program. A separate answer booklet makes the workbook reusable.

In preparing the workbook the skills of numerous people were called upon. The authors would like to formally thank:

- Mr. Thomas Curry, TAEG (retired), together with many NJROTC instructors, outlined the content. CAPT Sidney Hodge, NJROTC Area Manager, Area 7, was helpful in arranging the extended series of interviews with NJROTC instructors. LT Frank Rudden, NJROTC Instructor at Titusville High School, was particularly helpful in identifying topics for inclusion. CDR Russell Crosby, NJROTC Instructor at Maynard Evans High School, Orlando, carefully reviewed the workbook from an instructor's standpoint.

- Dr. William Morgan, Dr. Bill Dudley, Mr. George McCuistion, and LT Donna Nelson, of the Naval Historical Research Branch, carefully reviewed and critiqued the chapter on World War II.

- Mr. Archie Poole, Chief Illustrator of the Technical Data Branch, Naval Training Equipment Center, prepared some of the artwork. Ms. Catherine Williams of the University of Central Florida edited the text during the final stages.

- Special thanks are due Mr. Joseph Gilliam, CNET Coordinator of NJROTC Curriculum. Mr. Gilliam conceived the project and has been supportive in many ways.

- Other TAEG personnel, including Mr. Paul Scott, Mr. Robert Browning, Mr. Herschel Hughes, and Ms. Betty Pereyra, acted as reviewers throughout the preparation of the manuscript.

- TMCM(SS) LeRoy S. Miller, USN, Service School Command, Orlando, who participated in the Pacific submarine campaign, was kind enough to review the section on submarine warfare.

Grateful acknowledgment is made to:

- the Naval Historical Center for supplying World War II photographs.
- the History Department of the United States Military Academy at West Point for permission to use maps number 2 and 38b from the Campaign Atlas to the Second World War: Europe and the Mediterranean, 1980.

To the Students: The intent has been to produce a workbook that is readable, educational, and stimulating. It is hoped you will find the exercises particularly helpful as you increase your naval knowledge.

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CHAPTER I: THE NAVY IN WORLD WAR II

MOVEMENT TOWARD WORLD WAR II

** One repeated error made by the United States before World War II was letting its Navy fall apart. **

If you have ever heard the expression, "It seems like I've been here before!" you already understand the idea of historical perspective. Historical perspective(1) simply means that a person can only succeed in the future by seeing the meaning of the past. Without such vision a person or a country will make the same mistake over and over again. One such mistake seems to have happened several times within the United States before World War II.

During the last days of the Civil War (1861-1865) the Navy was strong. But after the war ended the country wanted to save money. There was the feeling that a big navy cost too much. There was the feeling that a country that wanted to develop railroads and other industries could not afford a big navy. To many people, there was no relationship between inland industries and ships. A few senior naval officers kept pointing out that historically a strong navy was as important to an America at peace as to an America at war, but they were ignored.

The Navy was given little support. With little money available for maintaining older ships, let alone building new ones, the Fleet fell apart. Meanwhile other navies kept on building. When a war broke out in South America among Chile, Bolivia, and Peru (1879-1884), the United States was shocked to see South American navies that were better than her own. The shock led to Congress ordering, in 1883, the building of modern, steel ships. The Atlanta, the Boston, and the Chicago, all steel-hulled, steam-powered cruisers, were built. A small dispatch boat, the Dolphin, was also built. For the next 10 years Congress kept on approving money for ship building. By 1889 the keels of the armored cruisers Texas and Maine had been laid down. By the end of 1891, the first three American battleships, the Indiana, the Massachusetts, and the Oregon, were under construction. At last the Navy was being restored.

(1) Underlined words are defined in the Glossary.

By World War I (1914-1918) the United States had rebuilt a strong navy which played an important part in winning the war. The surface fleet and the air arm of the Navy (which had been created in 1911) expanded greatly during World War I. When the war began, the Navy had 54 aircraft and only 48 pilots and student pilots. At the end of World War I there were 6,716 Navy and Marine officers, and over 2,000 aircraft! But the same historical pattern happened again. The country now had a large naval fleet to support during peacetime. This seemed too expensive. The war was long and brutal. After the war, the country again lost its historical perspective. The country had one great wish: to stay at peace.

WASHINGTON DISARMAMENT TREATIES

** After World War I, the United States tried to make treaties that would stop an arms buildup and therefore insure peace. The intention was good but the treaties did not work. **

To carry this out, the country favored isolation. The United States wanted to stay out of any more fighting. And keeping a powerful navy did not seem to fit this idea. Further, the country again wished to save money. Taking care of many ships did not seem to fit a tight economy either. Many people felt that the best way to insure peace was to isolate America from the rest of the world. One result of this attitude was that the United States refused to join the League of Nations. They felt that America could get along best by having no formal political allies. They also felt that we should cut spending on military or international projects that might even suggest the dreaded word, "war." Following this thinking, a major try to insure peace came in 1922 when President Harding called a meeting with the other four major naval powers: France, Italy, Japan and Britain. They were to discuss naval armament and Far East policies. All five signed a treaty, called the Naval Disarmament Treaty. In this treaty, each guaranteed the rights of the other to their island possessions in the Pacific. They also agreed to a 10 year holiday during which no nation would build a ship over 10,000 tons with guns bigger than eight inches. Other agreements to limit naval growth were made as well. Perhaps out of distrust or fear, almost all the other nations at once began to build. The United States converted two battle cruiser hulls into aircraft carrier hulls. Italy and Japan concentrated on heavy cruisers. Japan also began at once to fortify her Pacific bases because she knew that Britain and the United States would do nothing to stop her. In reality, Japan was claiming most of the Pacific. American naval officers objected to the Naval Disarmament Treaty as well as others signed during the next few years. Their major argument was that we "had been here before" and as a result had found ourselves with a weak Navy when we most needed a strong one. They were ignored.

THE U.S. NAVY IN THE PRE-WAR YEARS

** The Naval Command concentrated on developing new naval strategies: naval aviation, logistics and amphibious warfare. **

Because of the new restrictions on naval building during the 1920's and 1930's the Naval Command concentrated their efforts on developing strategies and newer weapons. They worked on naval aviation, the techniques of amphibious warfare and a system of detailed logistics. The Navy realized that if another war occurred, the Pacific already would be fully occupied by Japan. The Armed Forces would have to fight their way back across the Pacific. To accomplish this, the Navy would have to maintain the Fleet away from home for long periods of time. One major part of the Navy's new working plan was the science of logistics. Logistics is a system of supplying services and supplies -- oil, ammunition and food -- to the Fleet ships engaged in warfare. In case of a Pacific war, the Naval logistics system would have to solve the problem of freeing the Fleet from dependence on home bases.

The Navy also realized that aviation would become much more important. As early as 1921, the Navy had commissioned its first aircraft carrier and General Mitchell had shown that an airplane could bomb and sink a battleship. Aviation would no longer be mainly a scouting arm of the Navy. By 1938, the carrier task force had been developed as an important arm of the Navy.

Finally, and most importantly, the Navy realized that many operations would have to be amphibious. Amphibious warfare is the science of how to invade and occupy heavily defended enemy bases from water. The Naval Terms

Dictionary by John V. Noel, Captain, USN(RET), and Edward L. Beach, Captain, USN(RET), offers a definition of an amphibious force. It is "a naval force and landing force, together with supporting forces, who are trained, organized, and equipped for amphibious operations." The Marine Corps worked out the strategies of amphibious warfare. Amphibious warfare and its relation to logistics is very complicated. It not only means landing large numbers of troops on an enemy position, it means getting them there and supplying them, often for long periods of time. If you try and imagine all the cooperation and equipment necessary for a large amphibious operation you can see how difficult it is. It is like moving an entire floating city! Just think of all the messages involved in bringing troop ships together from different places! Add to the messages, methods of loading equipment, giving fire support to the troops as they fight their way to new positions, clearing the water of mines and supplying the troops once they have set up a beachhead. You can begin to see the complicated tasks involved in amphibious warfare. All these new ideas proved to be very important during World War II. In fact, some historians call the development of logistics "the secret weapon" that won the Pacific war.

RISE OF DICTATORSHIPS

** From 1936-1939 military dictatorships developed in Germany, Japan and Italy. **

While all these naval developments were taking place, the world was falling apart. Nineteen thirty-six saw the militant governments of Germany, Japan and Italy withdrawing from the League of Nations. Nineteen thirty-seven through 1939 saw Japan and Germany invade other nations and make them possessions. The same years saw England's Prime Minister Neville Chamberlain trying to keep peace by giving in to the increasing demands of Germany and Italy. This policy is often called appeasement. But the dictators were not appeased; instead they demanded more possessions. Finally, Adolph Hitler, dictator of Germany, demanded the Free City of Danzig and most of western Poland. England and France refused to agree and on 1 Sept. 1939 Hitler's armies invaded Poland. England and France declared war on 3 Sept. 1939. England and France had finally realized, at great cost to the world, that being blind to the errors of the past always means blindly repeating those errors in the future.

MULTIPLE CHOICE QUESTIONS:

1. "Historical perspective" means:

   a. understanding the present and the future by understanding the past.
   b. forgetting the past and going on to thinking about the present.
   c. a form of Naval warfare.

2. During the last days of the Civil War (1861-1865) the Navy was:

   a. strong.
   b. weak.
   c. destroyed.

3. During World War I, the Navy created its:

   a. battleship fleet.
   b. first rocketry division.
   c. aviation arm.

4. A repeated error made by the United States before World War II was refusing to:

   a. join the League of Nations.
   b. build inland industries.
   c. maintain its Navy.

5. Isolationism meant that:

   a. the United States did not want formal political allies and wanted to stay out of war.
   b. the United States did not want to sign any treaties, including peace treaties.
   c. political solutions proved to be a good way to keep out of war.

6. The Naval Disarmament Treaty was:

   a. an agreement between the United States and Russia to not engage in any Naval battles.
   b. an agreement among the United States, France, Italy, Japan, and Britain to stop building ships over 10,000 tons and with guns bigger than 8 inches.
   c. a worldwide success because each of the agreeing countries abided by the treaty.

7. Because of the Naval Disarmament Treaty:

   a. the Naval Command concentrated on new naval strategies.
   b. the Navy was allowed to build larger battleships.
   c. three admirals resigned in disgust.

8. The strategies of amphibious warfare were worked out mainly by the:

   a. Navy.
   b. Marines.
   c. Corps of Engineers.

9. Amphibious warfare is the science of:

   a. invading occupied and heavily defended enemy bases from water.
   b. how to supply troops once they have penetrated to the inner areas of an island.
   c. penetration bombing.

10. From 1936-1939:

   a. the world experienced the development of dictatorships in Germany, Japan, and Italy.
   b. the United States entered World War II.
   c. the United States joined the League of Nations.

TRUE OR FALSE QUESTIONS:

T F

1. After World War I there was the feeling that a large Navy cost too much. ____ ____

2. In 1883 the Congress ordered the building of large ships. ____ ____

3. The Atlanta, the Boston, and the Chicago were all early examples of aircraft carriers. ____ ____

4. World War I took place between 1914-1918. ____ ____

5. After World War I the Navy had many more aircraft than before the war. ____ ____

6. The Naval Disarmament Treaty was an attempt to limit the growth of world naval powers. ____ ____

7. The Naval Disarmament Treaty was a failure. ____ ____

8. Logistics is the science of how "to invade and occupy heavily defended enemy bases." ____ ____

9. Prime Minister Neville Chamberlain believed in appeasement. ____ ____

10. In 1939 Hitler's troops invaded France. ____ ____

VOCABULARY SKILLS:

Using the following vocabulary words, complete the sentences below. There is only one correct, appropriate word for each blank space.

perspective: seeing events or things in proper relationship to one another.

dictator: in government, a person who takes absolute control without the free consent of the people or any other right.

invade: to enter forcefully, as an enemy.

fleet: the largest organization of warships under the command of a single officer.

inland: in the interior part of a country or region.

isolationism: when a nation decides to maintain its rights and interests without any formal allies.

vision: the ability to see with the eyes, often used to suggest being able to see issues clearly.

economy: a term used when referring to the production of goods and services, their distribution, and consumption.

disarmament: the reduction or limitation of the size and equipment of a country's armed forces.

League of Nations: the first major organization of the states of the world dedicated to peace and international cooperation. It was founded after World War I in 1920.

international: between or among two or more nations.

strategy: the science or art of planning or directing large military movements and operations.

Free City of Danzig: a self-governing territory which included the N. Polish seaport of Danzig. (Hitler invaded in 1939 and made it a part of Germany. It is now part of Poland.)

amphibious warfare: warfare waged by using naval and landing forces embarked in ships or craft, involving a landing on a hostile shore.

allies: one who is united with you especially by treaty. (During World War II, England, the United States and Russia were allies.)

logistics: the system of supplying services and supplies to the fleet ships engaged in warfare.

appeasement: trying to keep peace by giving in to the increasing demands of others.

1. The United States, Russia, and England were __________during World War II.

2. The United States favored a policy of _______________ after World War I.

3. Kansas is an _____________ state.

4. Those who favored isolationism had a blurred _______________ of how to keep America safe.

5. The Naval Disarmament Treaty disallowed any combat ships over 10,000 tons from being added to the _________.

6. Hitler was a ruthless ____________ who wanted more and more territory.

7. _________________ is when a country agrees to reduce the size and power of its armed forces.

8. Without historical _______________a person or country is bound to repeat the errors of the past.

9. In 1939 Hitler's troops invaded the _______ _______ ___ _____________.

10. In order to move an entire fleet, the science of ______________ is necessary.

11. Hitler was willing to ________________ any country he believed he could capture.

12. The officer explained his ________________ for the naval battle.

13. The United States refused to join the _____________ __ __________.

14. The Marines were responsible for developing the techniques and strategies of ___________ ________________.

15. The League of Nations was truly an _________________ organization.

PRESIDENT ROOSEVELT TAKES STEPS TO PREPARE THE UNITED STATES

** As relations between the United States, Japan and Germany became more strained, President Franklin D. Roosevelt realized the United States might soon be involved in the war. He therefore prepared for war by building up naval forces in both the Atlantic and the Pacific and used these to aid our allies. **

After the European nations declared war on each other, President Roosevelt realized that it was probably only a matter of time until the United States also would become involved. He wanted us to be ready. He wanted us to have strong naval powers in both great oceans. For years we had kept fleets in the Pacific. We had ships near China. Now on 5 Sept. 1939, President Roosevelt ordered an American fleet into the Atlantic. He called it the Neutrality Patrol. Roosevelt had been warning America about the Axis (Germany, Italy and Japan) threat for many years. Now the threat was closer. The Neutrality Patrol's official task was to track belligerent ships and aircraft moving toward the United States or the West Indies. Unofficially, the Patrol allowed the Navy to recall men from the reserves. It also allowed the Navy to prepare older ships for battle. Germany was angered by this patrol. She wanted nothing to get in her way. By the end of 1940 the dictatorships of Germany and Japan had greatly expanded their conquests. Germany held Austria, most of Czechoslovakia, western and central Poland, Denmark, Belgium, Norway and the Netherlands (figure 1-1); Japan was pressing toward French Indochina. The United States was still not officially involved in the war but tensions were growing. Tension was particularly strong between the United States and Japan. For example, in May 1940, President Roosevelt transferred the Pacific fleet from the U.S. West Coast to Pearl Harbor, Hawaii. Japan was angered at having the powerful American fleet in what Japan considered her waters.

Diplomatic relations grew more strained because Japan was then involved in a war with China. To fight and win this war Japan needed large quantities of supplies. Earlier, the United States had sold Japan supplies. But since Japan had increased her aggressive behavior in the Pacific, the United States had become less friendly and less willing to sell Japan supplies. Japan had "informed" the Dutch authorities in the East Indies that oil resources in

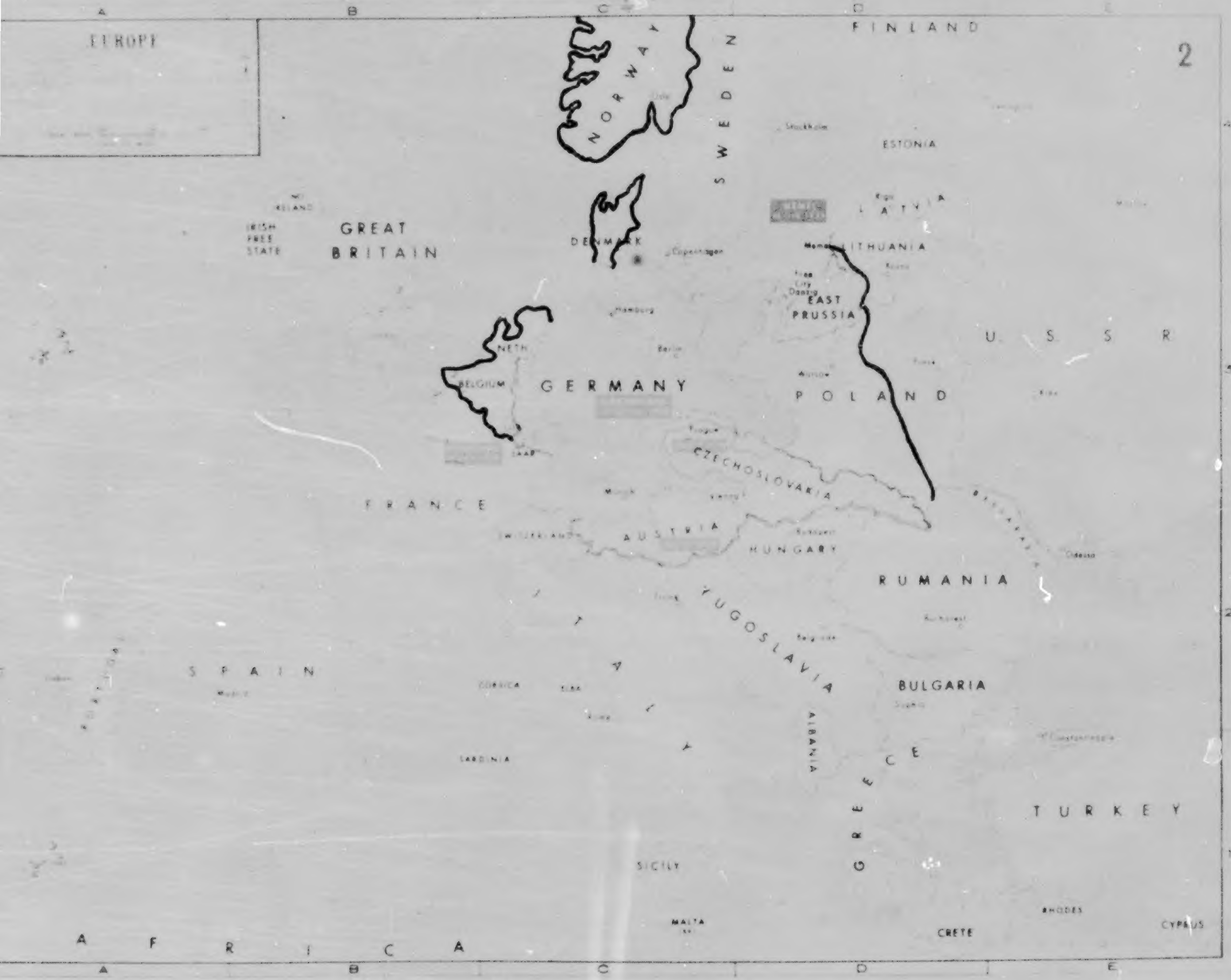


Figure 1-1. The German Mastery of Europe (Reprinted with Permission of the Department of History, United States Military Academy)

those islands would be "developed" jointly with Japan. It became clearer and clearer that Japan was out to dominate as much of the Pacific and its resources as she could. Certainly she planned to take over the East Indies and seize its mineral resources. In response, the United States showed Japan what it thought of her actions. First, President Roosevelt stopped the sale of aviation gasoline and scrap iron to Japan; then he stopped the sale of steel; then he stopped the sale of oil. At the same time in 1941 he ordered all Japanese assets in the United States frozen. This was close to declaring economic war and Japan knew it. In fact, it is true to say that although not one shot had been fired between the United States and Japan, an economic war was on. Japan knew she would have to find her war supplies somewhere else.

AGREEMENTS WITH U.S. ALLIES

** In order to prepare for the war, the United States began making formal agreements with its allies. **

At about this time, the United States began to close ranks with Britain. In Sept. 1940 the United States traded 50 over-age destroyers to Britain. In exchange, Britain gave the United States rent-free leases of 99 years on sites from Newfoundland to the West Indies for the establishment of American military and naval bases in the Atlantic. All of these bases were located in British possessions.

In March 1941, the United States and Britain signed another agreement called the Lend-Lease Act. This act allowed the United States to transfer war equipment to any country whose defense President Roosevelt judged "vital to the defense of the United States." You should realize that by this time Poland, Rumania, Bulgaria, Hungary, Luxembourg and France had also fallen to Germany's power. Britain itself was now threatened by German invasion. The Lend-Lease Act put the United States squarely behind Britain. Many Americans objected to the Lend-Lease Act. They felt the United States could still stay neutral to the Europeans' war and that this agreement was too strong. But President Roosevelt felt that without help Britain would fall. And if Britain fell the Atlantic Ocean would become a watery highway for Hitler's navy. And the United States could be next on his list of conquests.

During 1941, the United States came closer and closer to officially entering the war. The United States and Britain had a secret meeting in Washington and wrote the ABC-1 STAFF Agreement. The Agreement was that the United States Navy would help escort transatlantic convoys to Britain. This was very important because it was the United States' promise that it would fight to get needed supplies to Britain. They also planned for the United States' part if she officially entered the war. They agreed that the U.S. would concentrate mainly in the Atlantic to fight against the Germans; first, because of Germany's superior military strength and second, because of the immediate danger to Britain. Actually, from 1939-1941 Germany had treated American ships as if they were already in the war. For example, in Oct. 1939, the German cruiser, Deutschland, captured the S.S. City of Flint in the Atlantic. In May 1941, German submarines sank the S.S. Robin Moor in the South Atlantic. Other ships were attacked and sunk. The worst pre-war loss occurred during October. On 31 Oct., the destroyer Reuben James was torpedoed and sunk. Over 100 men were killed. Even yet there were Americans who wanted to avoid "direct involvement" in a war.

JAPANESE PLANNING

** The Japanese decided they would have to destroy the U.S. Pacific Fleet (figure 1-2). **

When Japan could no longer get oil from the United States, she knew she would have to get it from somewhere else. Otherwise her war in China would fail for lack of supplies. Japan decided that the only place to get the oil was in the Dutch East Indies; she would go in and take it. In order to do this safely, the Japanese reasoned they would have to destroy the U.S. Pacific Fleet now moored at Pearl Harbor and strong enough to interfere with Japanese maneuvers. In order to accomplish this, Japan assembled a strike force in the Southwest Pacific. The Pearl Harbor Strike Force first went into the Kurile Islands, off the coast of Japan, to await its orders. On 1 Dec., the Japanese Admiral Yamamoto radioed to his strike Force Commander, Vice Admiral Nagumo: "Niitaka Yama Nobore" or "climb Mount Niitaka." This was the code command meaning "proceed with the attack." The force, having already left the Kurile Islands on 26 Nov., made its way toward Pearl Harbor.

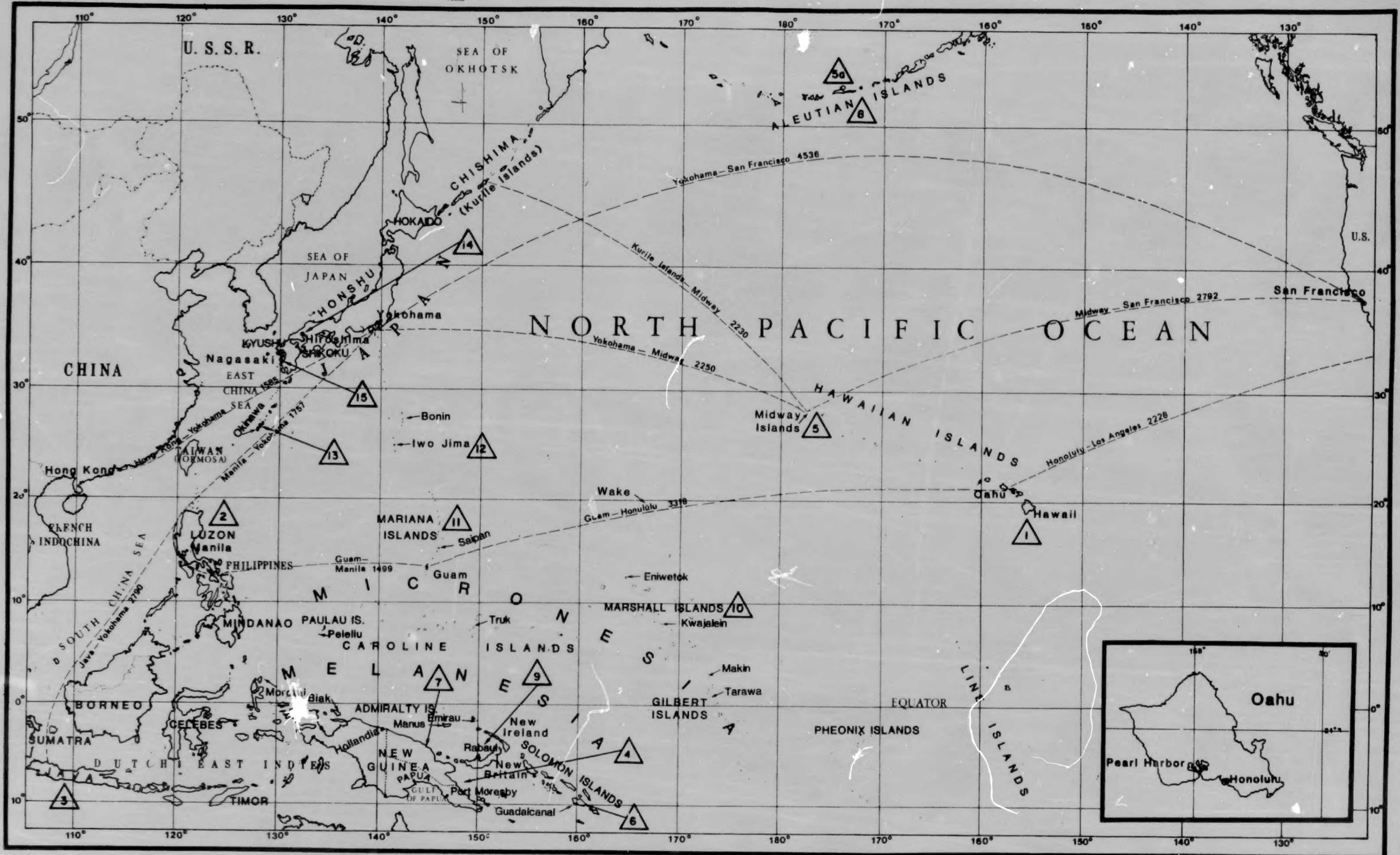


Figure 1-2. The Pacific Theater

(Numbers indicate the sequence of battles between the Allies and the Japanese throughout World War II. See legend in figure 1-2a.)

1	Pearl Harbor, Hawaii, 1941
2	Luzon, Philippines
3	Battle for Java
4	Battle of the Coral Sea
5	Battle for Midway
5a	Japanese Attacked Aleutian Islands--Diversionary Tactic
6	Guadalcanal
7	Battle for New Guinea
8	Reconquest of Attu and Kiska
9	Rings Around Rabaul
10	Battle of Marshall Islands
11	Battle of Saipan, Mariana Islands
12	Battle of Iwo Jima
13	Battle of Okinawa
14	Hiroshima Bombed
15	Nagasaki Bombed

Figure 1-2a. The Pacific Theater Sequence of Battles

THE ATTACK ON PEARL HARBOR

** The attack on Pearl Harbor came as a surprise and was an attempt by the Japanese to destroy American naval power in the Pacific. **

The Japanese Fleet was just north of the Hawaiian Islands at dawn. They had been traveling for several days hidden by stormy weather. But around the Islands the weather was clear. At about 0755 (local time) on 7 Dec. 1941, the event occurred that changed America's mind. America was shocked out of any neutral feelings when the Japanese attacked Pearl Harbor.

The attack literally came out of the blue, just as the base was preparing to make morning colors. Most of the American warships were neatly moored side by side. The troops were still in barracks. Many of the officers and enlisted men were on leave. No protective screen of light aircraft had been thrown out. In fact, the Navy really did not have enough planes to keep a constant patrol in all the hundreds of islands around Hawaii, and the Japanese Command realized this. The Japanese destroyed our planes while they were still on the ground.

The attack planes came in two waves. The first wave spread out and hit the moored ships, the airfields, and the barracks. The second attacked the same targets. Terrific damage was done. In all, about 360 Japanese planes flying from six carriers had disabled or destroyed 347 American planes. The Navy and the Marine Corps lost over 2000 and 800 were wounded. Of our eight battleships, the Arizona exploded (figure 1-3) and the Oklahoma capsized. Three others were so damaged, they sank. In a very short time, the Japanese had nearly destroyed the naval force at Pearl Harbor.

The Japanese believed that the attack would achieve several goals. By destroying the Pacific Fleet Japan believed she would not only disarm, but would frighten the United States. She believed the United States would be afraid to oppose any Japanese war actions in the Pacific. She believed the United States would be ready to bargain for a quick peace. Part of Japan's plan was to insist that the peace treaty give her the right to keep all her conquered territories in the East Indies. As a result, she would be guaranteed the oil and rubber she needed for her war in China. You could say that the attack on Pearl Harbor was

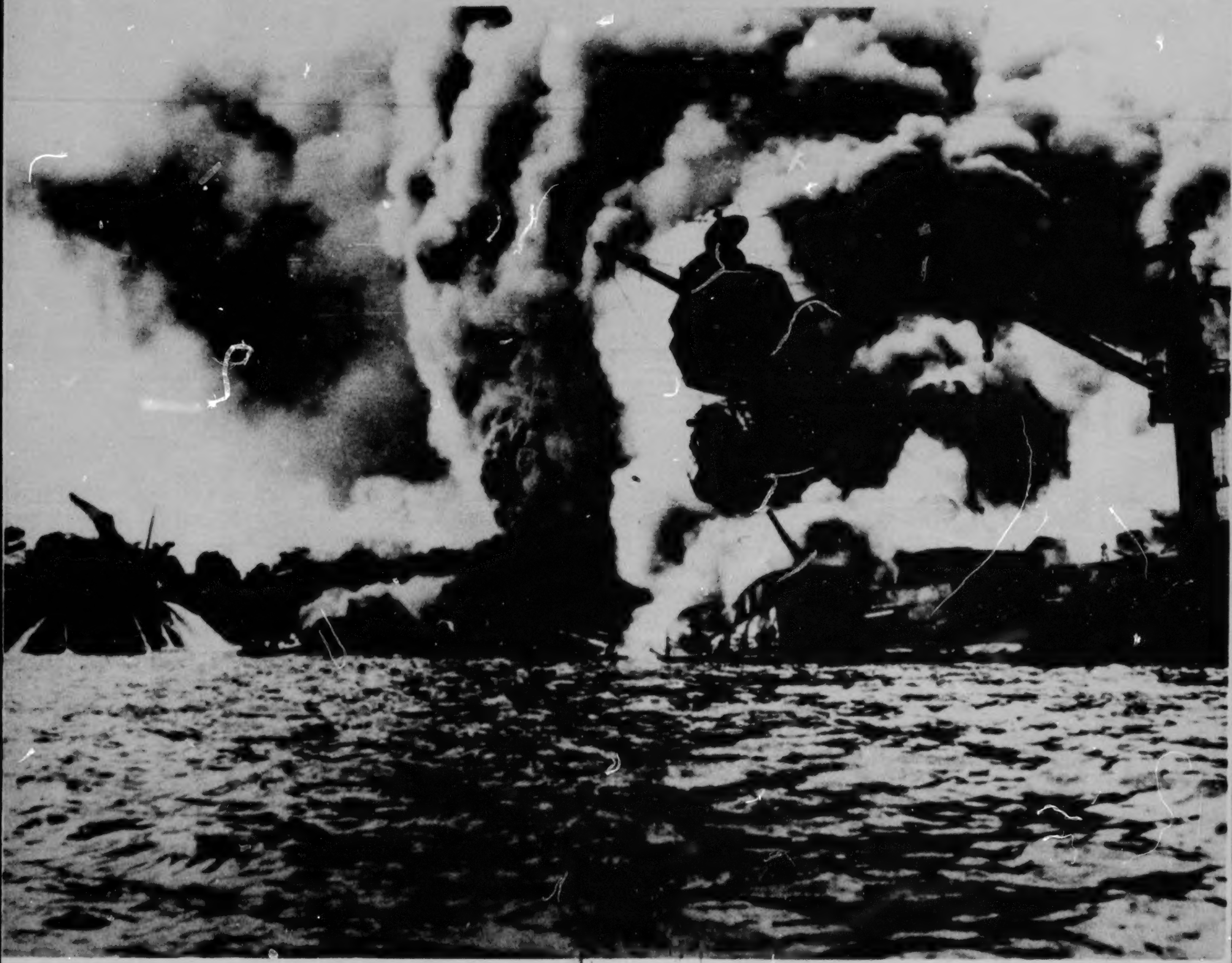


Figure 1-3. The Battleship Arizona Burns After Being Hit by Japanese Aircraft

part of Japan's secret plan to use military might to finally win her economic war with the United States. But this plan backfired.

AFTERMATH OF PEARL HARBOR

** Pearl Harbor ended any American feelings of neutrality. The attack failed in several ways: it missed the American aircraft carriers, the dry docks and repair yards, the fuel farm, and, finally, the Japanese did not try to occupy Pearl Harbor. **

When news of Pearl Harbor reached home, people were at first shocked and frightened. But then they were furious. Pearl Harbor ended any feelings of neutrality. Instead of being frightened, Americans were now united.

Furthermore, the Japanese attack had failed in three military ways. First, all the American aircraft carriers had been out at sea and so they were not damaged. Second, the Japanese planes had not bombed the dry dock and repair yards. These were used at once to repair damaged American ships. Third, the fuel farm was unharmed. Millions of gallons of fuel stored here were used later in the war to power American ships. Finally, the attack failed in another fundamental way. The Japanese did not realize they might need Pearl Harbor later as a key defense position. They did not try to occupy Pearl Harbor or at least to destroy all of its naval facilities.

Pearl Harbor had other important strategic results. The carriers that survived became the backbone of the Fleet. This, of course, made aircraft more important. Also a minor failure by the Japanese was to have lasting results later on in the war. Part of the Japanese strike force consisted of 30 submarines. Some of these even carried little two-man subs which were to detach and wait in the mouth of the harbor to torpedo any U.S. ships trying to escape. But the Japanese submarines proved to be the least effective weapon of their strike force. In fact, one of the two-man subs ran aground and a crewman was captured by an American Army sergeant. This crewman was the first Japanese prisoner of war. Partly because of its poor performance, the Japanese considered the submarine a minor weapon and did little to develop it. Later in the war, when they needed efficient submarine and anti-submarine forces, they did not have them.

One more major result of Pearl Harbor should be mentioned. The Japanese believed that the United States would back down and that the rest of the world would follow. Instead this surprise attack made Britain, Australia, New Zealand, South Africa, Canada, The Central American Republics and some South American countries Japan's enemies. Japan thought the attack would cut down resistance. Instead, the war became worldwide.

The Navy began to reorganize directly after Pearl Harbor. Admiral Ernest King became Commander in Chief, United States Fleet. He was also named Chief of Naval Operations (CNO). Admiral Chester W. Nimitz became the new Commander in Chief, Pacific Fleet (CINCPAC). His great task was to take control of what became the largest naval war effort the United States had ever faced. His order might be summarized as: stop the Japanese in the Pacific.

WORLD WAR II: ATLANTIC AND PACIFIC THEATERS

JAPANESE ATTACK THE PHILIPPINES AFTER PEARL HARBOR

** After Pearl Harbor, the Japanese attacked other islands in the Pacific. **

Directly after Pearl Harbor the Japanese moved swiftly, making other attacks in the Pacific. The most extensive of these were their invasions of the Philippine Islands (figure 1-4) and Malaya.

At this time, General Douglas MacArthur was commander of all troops in the Philippines. His idea had been to train the Philippine people as a self-protective army. But the Japanese attacks came before the army was ready. The Japanese attacked Luzon, the main island in the Philippines. They attacked all along its coast. They attacked at other points as well. And soon there were not enough American forces or well-trained Philippine forces and equipment to defend the long coastline. The American forces in Manila, the capital of the Philippines and America's strongest position in the Orient, withdrew toward the Bataan Peninsula, a finger of land 25 miles long and 20 miles wide on the southern coast of the island. General MacArthur finally withdrew his forces to the Bataan Peninsula as well. The idea was to hold a position there. But they couldn't. Supplies were not adequate and the malaria was so bad that soon only one fourth of the forces were fit enough to fight. MacArthur was ordered to leave and go to Australia to assume

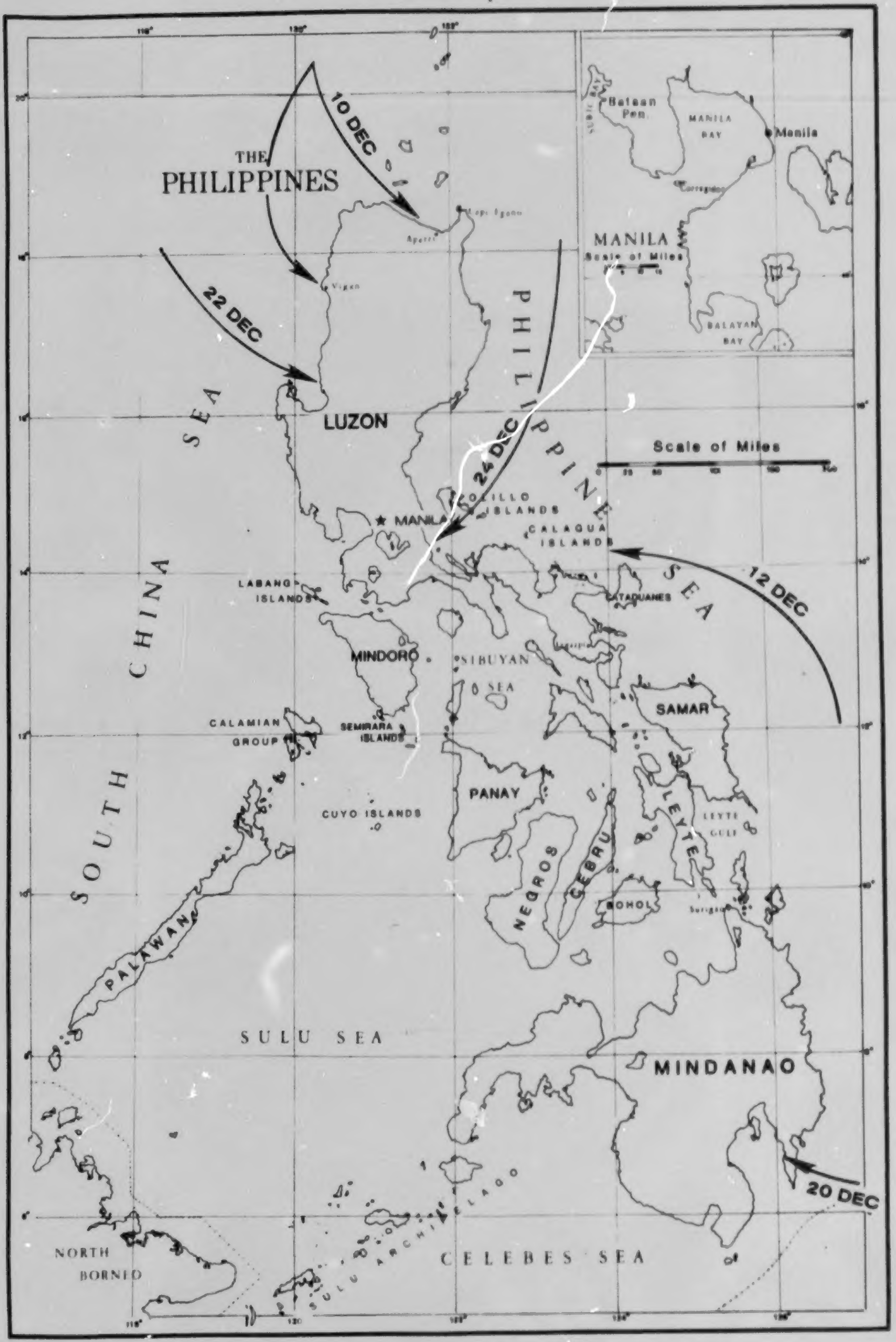


Figure 1-4. The Invasion of the Philippines by the Japanese December 1941; Arrows Indicate Invasion Routes and Dates

command of the newly formed Southwest Pacific Area. Eventually the forces had to surrender. They did, and so the fighting shifted to the fortress island of Corregidor which was only two miles from the Bataan Peninsula.

Corregidor, guarding the entrance to Manila Bay, was considered one of the strongest and most defendable places in the Pacific, mainly because of its rock terrain and the 15,000 troops stationed there. There were three high hill masses there. The highest was 550 feet. These hills were filled with gun emplacements, many of which were securely mounted behind concrete slabs or in open pits. The guns were very effective against shelling from offshore ships. But they were open to attacks from aircraft. The internal structure of Corregidor developed into a defense problem as well. Corregidor had a tunnel system that gave underground protection for food stores, ammunition, medical spaces, and communications. But the tunnels had a weakness. The air supply in the tunnels was poor. The Philippines are very hot and humid. When filled with sweating men, the tunnels on Corregidor became terribly hot.

Corregidor became the headquarters of all United States and Philippine forces in the Philippine Islands. It was hoped that the forces could stop the Japanese here. But the Japanese were too strong and well equipped. The Japanese formed a powerful sea and air blockade and from Bataan they began to shell the island. Attempts to break the blockade failed and so the forces could get no supplies; food grew scarce. Rations were cut again and again but the American forces kept fighting. Lt. Gen. Jonathan N. Wainwright had been commanding Corregidor since leaving the Peninsula. He inspired his troops by promising to hold Corregidor. He knew its importance. He knew it protected the best harbor under the United States flag in the Western Pacific, and that it was strategic to the Japanese because it crossed the North-South shipping lines between Japan and the South China Sea. He said Japan would have to walk over him to take Corregidor.

Wainwright and his forces fought bravely. But the American forces were too few and their supplies too thin. The days and months dragged on and the Japanese kept on shelling. By the time the Japanese finally took what was left of the island, American forces had suffered starvation, thirst and disease. They had also suffered the worst bombardment the Orient had ever seen.

The surrender came on 6 May 1942. This date will live forever in sorrow and pride. The sorrow is for the American losses, of over 2,000 killed and 11,500 made prisoners. The pride is for the unbelievable bravery of American forces. It is amazing to realize that the American defenders of Corregidor inflicted five times as many casualties as they received.

The Japanese continued to roll on through the Philippines. The islands, once the pride of America, were to be lost.

MULTIPLE CHOICE QUESTIONS:

1. As President Roosevelt realized that the United States might be drawn into the war, he proposed:

   a. combining our naval fleet with Britain's.
   b. reducing naval power in the Pacific and increasing it in the Atlantic.
   c. building up American naval power in both the Pacific and Atlantic oceans.

2. The Neutrality Patrol's official task was to:

   a. track belligerent ships and aircraft moving toward the United States or the West Indies.
   b. convoy British ships on their way to Russia.
   c. guard against the attack by Japanese ships in the Pacific.

3. When Japan became more aggressive in the Pacific, she planned to:

   a. persuade the rulers of the East Indies to sell her oil at a much reduced rate.
   b. take over the East Indies and seize its mineral resources.
   c. destroy all of the East Indies

4. In Sept. 1940, the United States:

   a. traded 50 destroyers to Britain in exchange for 99-year leases for bases in the Atlantic.
   b. attacked the Japanese forces in the East Indies.
   c. had a meeting in Washington and wrote the ABC/Staff Agreement.

5. The ABC/Staff Agreement was important because:

   a. it was the United States' promise that they would fight to get needed supplies to Britain.
   b. it outlined the United States' naval strategy in the Pacific.
   c. it allowed the United States to transfer war equipment to any country whose defense President Roosevelt judged vital to the welfare of the United States.

6. The worst pre-war loss suffered by the United States was:

   a. the destroyer Reuben James.
   b. the gunboats off the coast of China.
   c. the battleship Arizona.

7. The first wave of Japanese planes at Pearl Harbor attacked:

   a. the moored ships, the airfields, and the barracks.
   b. the battleships, the destroyers, and the aircraft carriers.
   c. the oil reserves, the barracks, and the moored ships.

8. The Japanese attack on Pearl Harbor was not fully successful because:
   a. they missed major targets in the harbor.
   b. they failed to hit the carriers, the dry dock, repair yards, and the fuel farm.
   c. they occupied Pearl Harbor and were later attacked by fighters from the U.S. carriers.

9. When the Japanese submarines performed badly at Pearl Harbor, the Japanese:
   a. began a large submarine development program.
   b. discounted the submarine as a major weapon.
   c. brought in German submarines for assistance.

10. Admiral Chester W. Nimitz' orders after Pearl Harbor were:
   a. retreat to Corregidor.
   b. stop the Japanese in the Pacific.
   c. supervise the rebuilding of Pearl Harbor.

TRUE OR FALSE QUESTIONS:

T F

1. After Pearl Harbor the Japanese moved cautiously and avoided making other attacks in the Pacific. ____ ____

2. The Japanese believed a success at Pearl Harbor would cripple the United States' ability to fight in the Pacific. ____ ____

3. Corregidor was considered one of the strongest defendable places in the Pacific because of its flat terrain. ____ ____

4. Two of the most extensive Japanese attacks in the Pacific were in the Philippines and Malaya. ____ ____

5. After MacArthur left, Corregidor's command passed to Admiral King. ____ ____

6. When Japan increased her aggression in the Philippines, the United States responded by refusing to sell her supplies. ____ ____

7. Luzon is the major island of the Philippines. ____ ____

8. Neutrality is the attempt to avoid involvement in a war by avoiding allegiance with any participant. ____ ____

9. By 1941 Germany had attacked and captured Poland, Denmark, Holland, Belgium, Luxembourg, France, and Britain. ____ ____

10. Japan was angry when Roosevelt transferred the Pacific Fleet from the West Coast to Pearl Harbor because Japan considered the Pacific waters her territory. ____ ____

VOCABULARY SKILLS:

Using the following vocabulary words, complete the sentences below. There is only one correct, appropriate word for each blank space.

axis: the alliance of Germany, Japan, and Italy during World War II.

belligerent: a warlike or aggressive attitude. (The participants in a battle are referred to as belligerents.)

resources: a natural source of wealth like oil or coal.

dominate: to rule or control.

assets: total personal property.

conquests: the act of gaining something by using force.

transatlantic: crossing or extending across the Atlantic Ocean.

convoy: merchant ships or supply ships escorted by warships and sometimes aircraft.

1. The alliance of Germany, Italy, and Japan became known as the ____________ powers.
2. In demanding that the Dutch East Indies develop its resources jointly with Japan, Japan showed its ________________ attitude.
3. One could say that a person's intelligence and emotional stability are important natural ______________.
4. The United States promised to provide British ships _______________ convoys if necessary.
5. By 1941, Germany had made many ________________ in Western Europe.
6. A collection of merchant ships protected by warships is a __________.
7. Germany eventually wished to ______________ all of Europe.
8. An individual's personal ________________ might be considered his property.

THE NAVY IN THE ATLANTIC

** The Navy's main goal in the Atlantic was to combat the German submarine. **

The Navy's main goal in the Atlantic was to find and destroy German submarines (U-boats). (Figure 1-5 shows a German U-Boat.) Unlike Japan, Germany fully understood the submarine's value as a weapon. Germany had successfully used the submarine in World War I; in World War II they used it again.

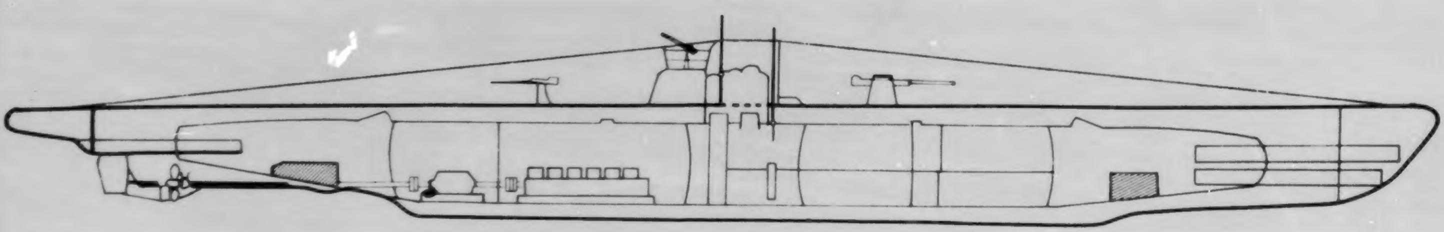
Up to April 1940, 688,000 gross tons of Allied and neutral shipping had been sunk; by 17 March 1941, German U-boats had sunk an additional 2,314,000 tons. The United States and Britain realized they had to stop the Germans. They had to keep the sea lanes open for needed supplies. Without supplies there could be no victory in Europe.

Cooperation was the key to victory. Ships and planes had to work together to find and destroy the German submarines. This work took not only excellent equipment but human self-control as well. Realize that much of a crew's time was spent in searching for the submarines. Hour after hour of searching became boring, yet each man was expected to stay totally alert all the time. They forced themselves to stay alert until the time for battle came. Then they used seven major weapons, and these weapons were so effective that by May 1943 we succeeded in sinking 43 German U-boats. This German defeat was the turning point in the Battle of the Atlantic.

COUNTERMEASURES AGAINST THE U-BOATS (figure 1-6)

Technology

Sonar, radar and sonobuoys were all electronic devices used to discover the presence of a submarine. These were refined as the war went on. Sonar bounces a sound wave off the metal hull of a submarine to detect its presence. Radar uses electrical impulses and is more precise because it not only finds an object, but measures its range, bearing, and elevation as well. The sonobuoy is a sound receiver-transmitter dropped from an aircraft to pick up submarine noises and send these back to the plane. All of these inventions contributed to finding and destroying submarines.



Length: 213.3 feet
Width: 19.8 feet
Depth: 13.0 feet

Scale: 1" = 21.3 feet

Figure 1-5. German U-Boat (750 ton class)

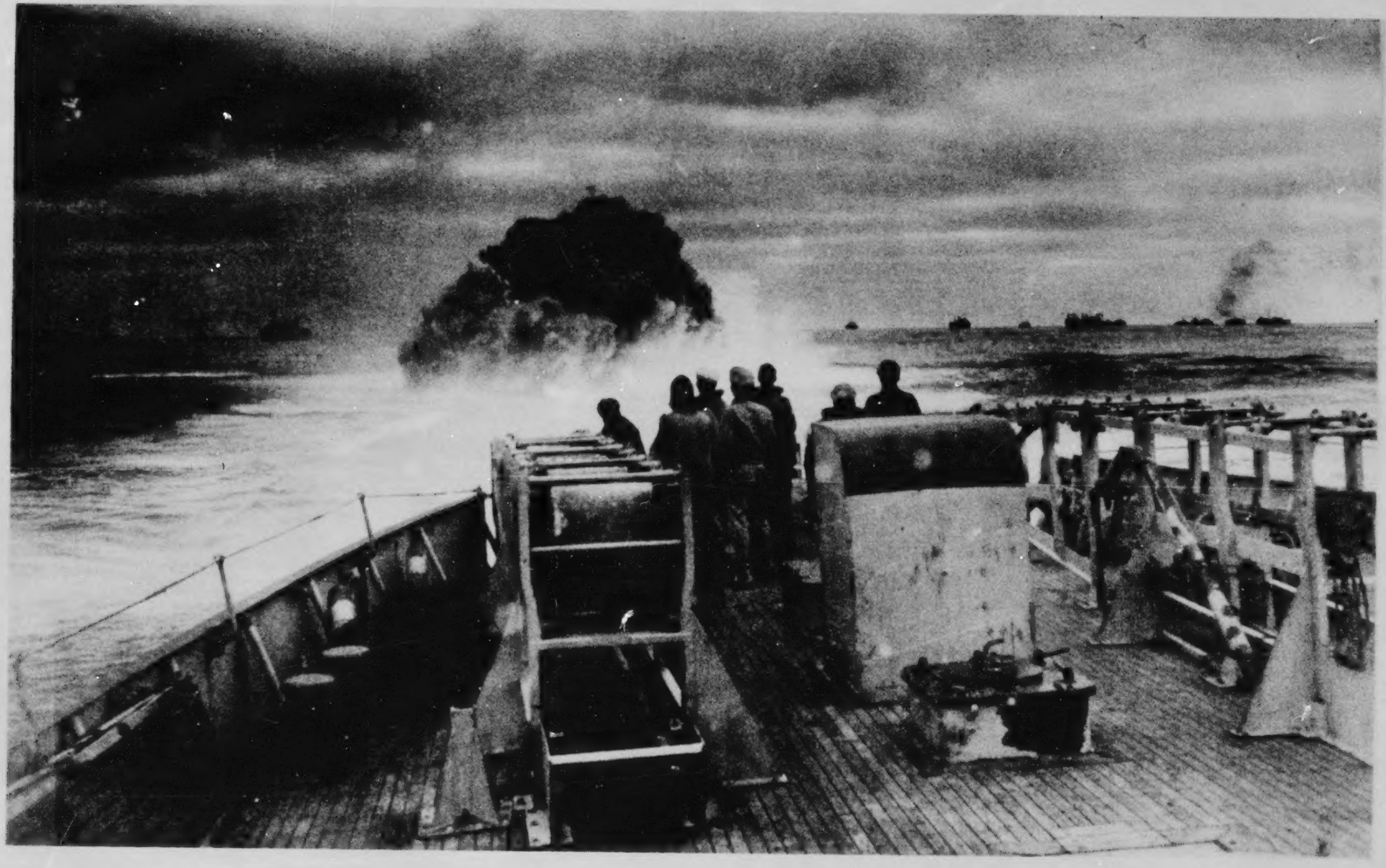


Figure 1-6. USCGC "Spencer" Sinks German Submarine U-175 on 17 April 1943

Coastal Convoys

Unprotected ships were hunted by the German submarines. The Germans counted on the subs to destroy or cut off the supplies flowing from America to Europe and from the West to Russia. In this effort the German subs actually got close enough to see the lights of cities on the east coast of the United States. To protect the supply ships, the convoy idea was developed. Merchant ships would cluster in protected harbors at night (figure 1-7). They would travel only during the day protected by warships. When the convoys travelled in the open seas, the convoying men-of-war would take protective positions around the merchant ships, and then stop at the next protected harbor. These harbors were protected by mines, blimps and surface vessels. The blimps were lookouts. If a sub was sighted by a blimp, the blimp would call surface vessels or planes to attack. The blimps, ships and planes worked as a team. Of course, convoys did not only operate along our coasts. They often made trans-oceanic voyages and it was here in unfriendly waters and along unfriendly coasts that they suffered their greatest losses.

Air Patrols

Air patrols were flown by planes designed for hunting and sinking submarines. One of the most successful of these patrol planes or flying boats was the PBY, also called Catalina. They were equipped with radar and depth charges. As long range planes carrying a lot of fuel, they could fly and hunt for long periods of time. When an enemy submarine surfaced to recharge its batteries, the PBYs would attack. Besides destroying submarines, the PBYs had other important uses. Sometimes they would see subs and signal to surface ships, which would attack. PBYs often saved the survivors of sub attacks.

Destroyer Escorts (DE)

The DE was smaller than the full-sized destroyer and was specially designed for anti-submarine

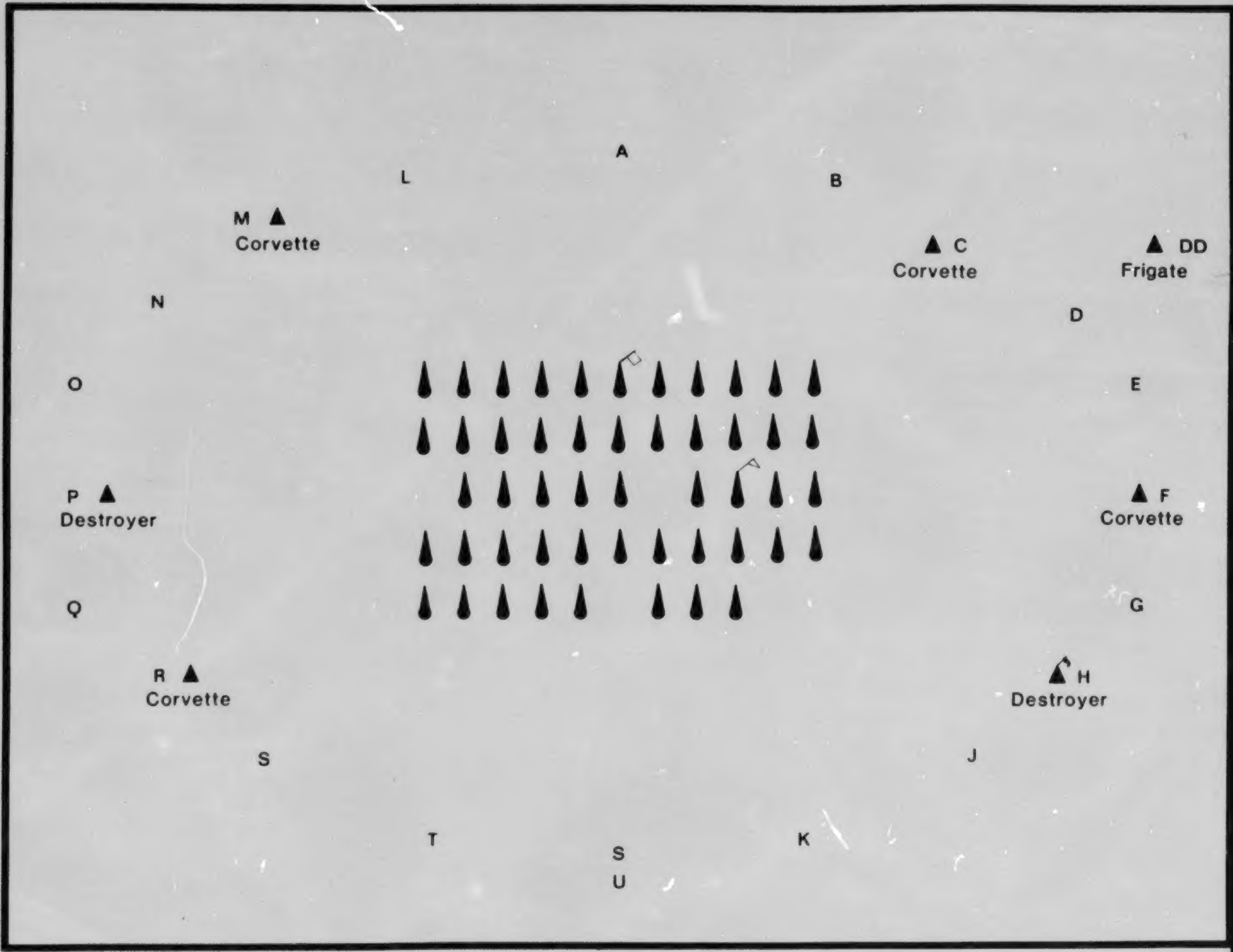


Figure 1-7. A Convoy

warfare. On the forecastle she carried a hedgehog. The hedgehog threw a contact-fused projectile into the water ahead of the DE when the submarine's underwater position was made certain by sonar. Since the hedgehog only exploded on contact with a sub, an explosion meant a hit.

Escort Carriers

The escort carrier was the smallest aircraft carrier. It carried between 21 and 30 planes. It was used to provide air protection farther out at sea. Its aircraft also carried depth bombs. Most important, the escort carriers teamed up with the DE's to form "hunter-killer" groups.

Building Yards

From 1940-1945 the United States produced more vessels than in all its past history. Among them were submarines, attack ships and merchant ships. The United States was able to put together many ships in a few days or weeks for several reasons. First, the shipyards worked on 24 hour shifts. Second, the yards used mass production techniques. Working in factories all over the country, thousands of people made the individual pieces first. They were then transported to a shipyard and assembled with other pieces which had been mass-produced somewhere else. For example, a plant in Denver, Colorado, made thousands of sections for destroyer escorts. These sections were then shipped by rail to California and put together with other sections at Mare Island Navy Yard. Similar team efforts occurred at factories and shipyards throughout the United States.

Mass Training

The U.S. Navy set up what could be called an anti-submarine university. There were several schools training specialists in using sound systems and 15 anti-submarine training centers. Graduates left these schools to man the anti-submarine vessels. The crews were well able to operate the equipment designed for anti-submarine warfare. Realizing the importance of teamwork in the submarines, the Navy suspended its practice of

> shifting officers from one kind of duty to another. Because of the amazing mass training system, the development of new weapon systems and strategies, and the dedication of the men involved in anti-submarine warfare, the Germans were eventually forced to retreat.

Statistics and descriptions of weapon systems do not explain the difficulty of anti-submarine warfare in the Atlantic. Neither do they show the dedication of our forces. Perhaps the best example illustrating the difficulties met by our convoys and the dedication they showed is illustrated by the North Russian convoys. Weather conditions were worse here than on any route in the world. These convoys met heavy gales, snow, and sleet storms. Ice offered an added danger to navigation. If a sailor fell overboard in Arctic waters he would freeze in a few minutes. In spite of all these hazards, the port of Murmansk in Russia received the supplies it needed. Some historians believe this allowed the Soviet Union to hold out against the Germans.

The German submarines kept up their attacks on Allied shipping until the end of the war. But the Allies' abilities to successfully destroy the submarines while continuing to protect supply ships, and America's ability to build more and more ships, eventually offset the Germans' submarine strength.

MULTIPLE CHOICE QUESTIONS:

1. The greatest danger to the Allies in the Atlantic was:

   a. amphibious landings.
   b. the U-boat.
   c. the newly designed German destroyer escort.

2. When they spotted German submarines, blimps:

   a. sent messages to surface vessels and aircraft.
   b. attacked with depth charges.
   c. wired the convoys to change course.

3. German submarines got so close to the east coast of the United States, they:

   a. could see the lights of the coastal cities.
   b. actually attacked and sunk two merchant ships in New York harbor.
   c. frightened President Roosevelt into ordering a protective blockade of Miami harbor.

4. PBYs were also known as:

   a. Catalinas.
   b. Escort Carriers.
   c. DE's.

5. A hedgehog was:

   a. a weapon that threw anti-submarine bombs at a U-boat.
   b. a light fighter carried on a baby flattop.
   c. a depth charge weapon dropped by the Catalina.

6. Building yards:

   a. limited their manufacturing to DE's and CE's and as a result were exceptionally efficient.
   b. were concentrated primarily on the east coast and therefore could quickly transport and assemble their products.
   c. applied the mass-production methods of auto manufacturing to shipbuilding.

7. Murmansk was:

   a. a port off the coast of Australia that six German U-boats destroyed in 1942.
   b. a strategic Russian port in the North Atlantic.
   c. the second most important Russian Admiral during the Battle of the Atlantic.

8. The dangers in convoy work in the North Atlantic were increased:

   a. by the rough seas and ice cold waters.
   b. because the Russians had no protective aircraft to protect ships.
   c. because the United States and Russia were not allies.

TRUE OR FALSE QUESTIONS:

T F

1. Mass training of personnel can be considered one of the major weapons used by the United States to combat the German U-boat. ____ ____

2. The escort carrier (or baby flattop) carried the search aircraft far to sea, where land-based planes could not reach. ____ ____

3. Sonar, radar, and sonobuoys were electronic devices used by the submarines to combat the surface craft. ____ ____

4. The "Battle of the Atlantic" was a combined effort by the United States, Britain, and France to keep the sea lanes open to Europe. ____ ____

5. Blimps were an important part of the convoy strategy. ____ ____

VOCABULARY SKILLS:

Using the following vocabulary words, complete the sentences below. There is only one correct, appropriate word for each blank space. Four words are not appropriate for any space.

hedgehog
radar
coastal convoy
Odessa
sonobuoy
Prime Minister Churchill
sea lanes
protected harbors (anchorages)
logistics
flying boat
Europe
Australia
Prime Minister Chamberlain

1. The __________ __________ was developed to protect supply ships that were being hunted by German submarines.
2. During the night the supply ships would cluster in __________ __________.
3. Sonar, _______, and __________(s) were all electronic devices used to discover the presence of a submarine.
4. One type of plane specifically designed for hunting and sinking submarines was nicknamed the __________ __________.
5. _______ __________ __________ of England tried to deal peacefully with the Germans before World War II.
6. Keeping the Atlantic _____ _______ open for merchant ships was vital if the allies were to win the war in Europe.
7. The __________ was an exploding anti-submarine weapon.
8. The system of supplying services and supplies to fleet ships engaged in warfare is called __________.

BRAIN TEASERS:

1. Write to the Museum of Science and Industry in Chicago, Illinois, and explain that your class is studying anti-submarine warfare in the Atlantic during World War II. Ask them to send you information on the captured German submarine U-505 on display at the museum. This sub was captured by CAPT Dan Gallery's group led by the escort carrier USS Guadalcanal. You should also do library research to gain additional information.

2. Go to the library and do research on the modern nuclear submarine. Compare and contrast the U-boat with this much later relative. In what basic ways do you think they are similar? In what fundamental ways are they different?

3. Admiral Donitz, German U-boat commander, thought up a tactic which he called the "wolfpack" tactic. First, as a class ask yourselves what the name itself suggests and try to imagine such a tactic without doing any research. Then go to the library and research the actual tactic. How close was your original imaginative guess? Where were you wrong?

Suggested References:

Bekker, Cajus. Hitler's Naval War. 1975. Doubleday, New York.

Morison, Samuel E. The Two-Ocean War; A Short History of the United States Navy in the Second World War. 1963. Atlantic Monthly Press. Little, Brown & Co., Boston.

4. Find Murmansk on a World War II map of Russia. Research the weather and sea conditions of the area. Locate another area in the world where weather conditions are similar.

WORLD WAR II: ATLANTIC AND EUROPEAN THEATERS

** In 1942 America and Britain joined forces to attack the Germans in North Africa. This invasion resulted in the first major defeat of the Axis. **

By 1942 Britain had been fighting the German forces for three years. Russia too had met the German Army. Both were losing. In the spring of 1942 America joined the war to help Britain. Their commands met to make plans that would start to turn the tide against the Germans. The American command wanted to make a direct amphibious assault on Europe. They wanted to establish a beachhead in France and then fight an overland war into the heart of Germany. The British felt that Germany was too strong for this approach. Sir Winston Churchill, Prime Minister of England, felt that an attack on outlying German positions would work better.

Churchill suggested that French North Africa was the best place to attack. Germany was getting stronger and stronger here. In fact, German Field Marshall Rommel, the Desert Fox, was badly beating the British forces. He was getting dangerously close to the Suez Canal, a tremendously important shipping lane which was controlled by the British. An attack on German positions along the coast of Africa would take reinforcements away from Rommel and from other German positions in Africa and on the beaches of Europe.

The Allies agreed. The plan called for a giant three-pronged amphibious attack on North Africa (figure 1-8). It had one main goal: take Morocco and Algeria and clear Germany's forces out of the rest of North Africa. The plan was called Operation Torch. It involved three forces composed of British and American troops under the command of General Eisenhower:

(1) The Western Naval Task Force was to land near the port of Casablanca in French Morocco.

(2) The Central Naval Task Force made up of British and American Forces was to invade Oran, Algeria.

(3) The Eastern Naval Task Force was to attack Algiers.

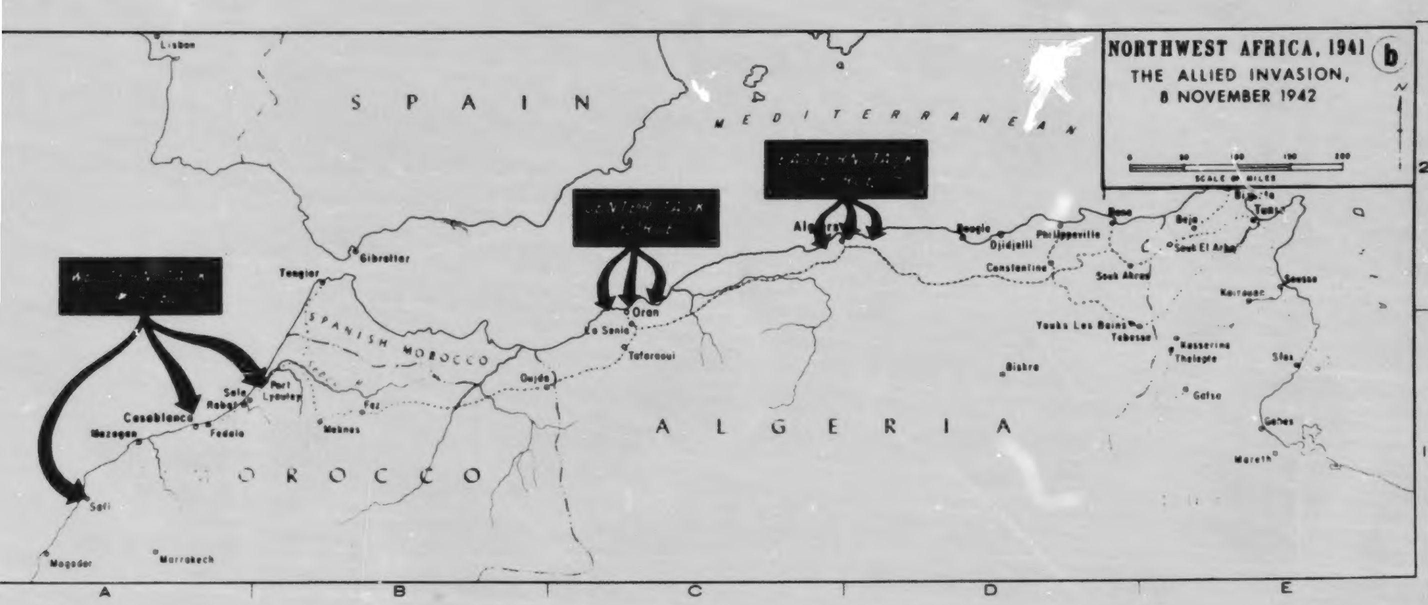


Figure 1-8. Operation Torch, North Africa

The main worry in this operation was how the Vichy French Forces would react. The Vichy were the French who cooperated with Germany. The Vichy French Navy resisted at Casablanca but U.S. Navy gunfire overcame them. There was no resistance at Oran or Algiers. The fighting in North Africa went on until May 1943. By the time the fighting ended, the Allies had captured the entire German African corps -- 275,000 enemy soldiers. They had also sunk 433,000 tons of enemy shipping. The North African operations achieved the Allies' goal: to take Morocco and Algeria and clear the Germans out of the rest of North Africa. This was the first big Axis defeat.

ON THE EASTERN FRONT

** The long Battle of Stalingrad in Russia turned the tide against the Germans on the Eastern Front. **

At about this same time the Russians won a great victory. In the winter of 1942-43 a large German army had tried to capture Stalingrad, an industrial city in Russia that was on Germany's direct line into the oil-rich areas of Russia. If Germany could take Stalingrad, a firm position would be established covering Germany's line into the oil regions. Instead, after months of fighting, the Russians surrounded the Germans and defeated them, eventually capturing 300,000 prisoners. The Battle of Stalingrad turned the tide against the Germans on the Eastern Front. Now the Russians, instead of being on the defensive, began to push their way back across Europe towards Germany. In other parts of Russia, the Germans were also starting to lose. Two years later the Russians would enter Berlin, Germany.

CASABLANCA CONFERENCE

** In 1943, President Roosevelt and Prime Minister Churchill met at Casablanca to settle the next steps in Allied strategy. **

In Jan. 1943, President Roosevelt and Prime Minister Churchill met in Casablanca to decide what their next actions should be. After long discussions and compromises they eventually came to three major decisions:

1. German submarines in the Atlantic had to be stopped.

2. The next move against the Axis would be an invasion of Sicily.

3. They would eventually demand nothing short of total surrender of Germany, Italy, and Japan.

OPERATION HUSKY: SICILY

** The Allies invaded and captured Sicily. This was the first invasion of Axis territory. **

Under the Command of General Eisenhower, the combined Allied attack on Sicily began on 9 July 1943. Sicily is an island off the coast of Italy. To fully reopen the Mediterranean Sea to Allied shipping it was necessary to occupy Sicily and Sardinia. The naval side of the invasion was planned and directed by the British Admiral, Sir Andrew Cunningham. Admiral Hewitt, who had commanded the Navy Task Force in North Africa, commanded the American amphibious forces again. Field Marshall Montgomery commanded the British Eighth Army and General Patton commanded his American Seventh Army. Again the campaign was a collective Allied effort composed of multiple branches of the Armed Forces. The Allies' assault that landed in Sicily was larger in size than even the Normandy assault that took place later in 1944.

The Sicilian campaign lasted only 38 days. The Allies' strength was mainly sea power, using many kinds of newly developed amphibious ships. But air cover was also tremendously important. During the amphibious approach, air support was so good and enemy aircraft was kept so busy or pinned down, that the approaching convoys suffered minimum damage. In addition, the air cover made numerous bombing runs to soften the enemy. In short, allied air power was vastly superior to that of the Germans and the Italians during the invasion of Sicily. The air cover very definitely contributed to the success of the landing forces by the time they hit the beaches. Once landed, the forces of General Patton and Field Marshall Montgomery defeated the retreating enemy. By 17 Aug. Sicily was under Allied control. The Allies now prepared to invade Italy.

OPERATION AVALANCHE: THE INVASION OF ITALY

** The invasion of Italy was very difficult because of the concentrated German troops and air power located there. **

Like the operation against Sicily, the invasion of Italy was a partnership between British and American forces. The troops of both countries worked together, side by side, both on land and at sea. Even though the Italians surrendered on the eve of 8 Sept. 1943, just before the invasion of the port city, Salerno, the invasion was very difficult because Italy was filled with German troops.

In addition to many troops, the Germans had 600 tanks in the area. The air cover for Allied landing troops was not strong enough. As a result, the Allies were pinned down on the beach.

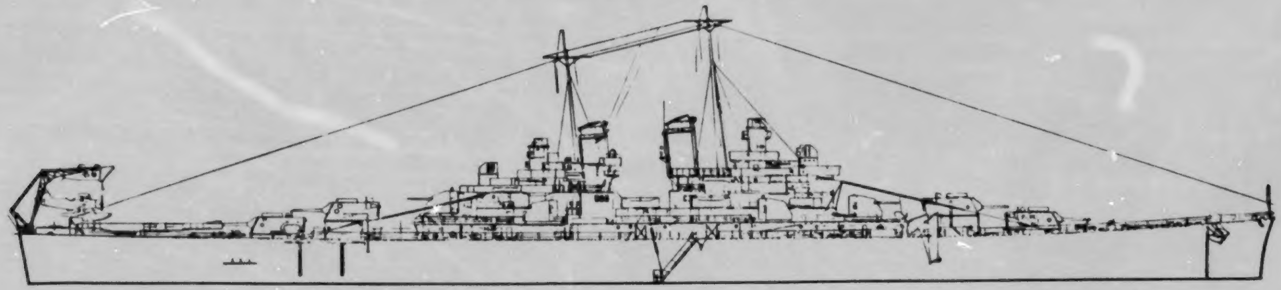
The American Navy saved the day, delivering fire support that finally turned back the Germans. The cruiser Savannah alone fired 645 rounds of 6-inch shells. But it was a hard battle and the effectiveness of the ships was counteracted by the German Air Force's fierce attacks. The Germans used a new radio controlled bomb. Many ships were damaged (figure 1-9).

After heavy losses, the Allies established a beachhead on Salerno. In September, the Germans withdrew to a new defense line north of Naples. By 1 Oct. the Fifth Army occupied Naples. The Seabees feverishly worked to clear the harbor and the Allies began their buildup to move north.

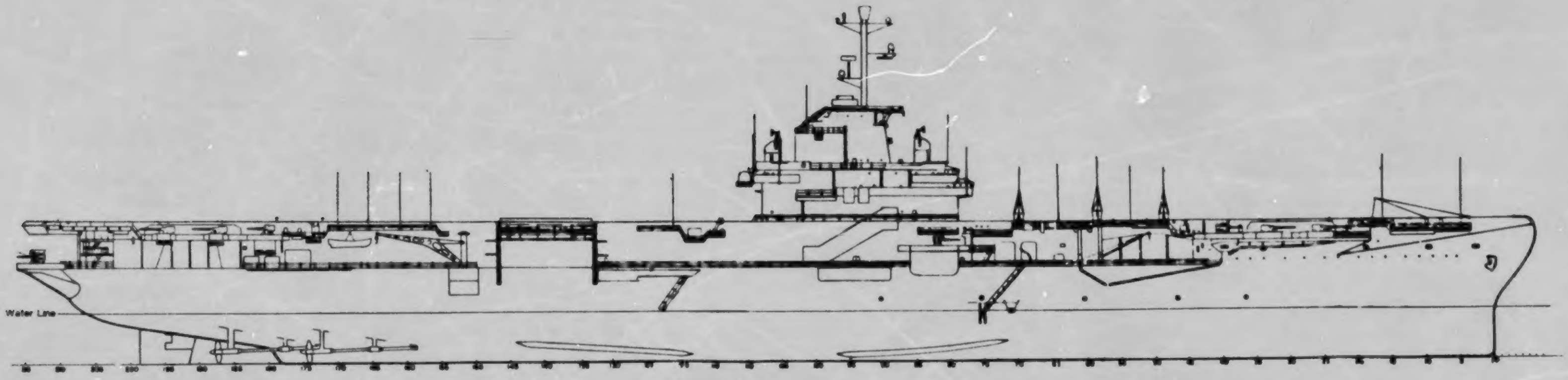
ANZIO

** The next landing in Italy was at Anzio. **

The next landing was at Anzio, 37 miles south of Rome. This was done to leapfrog over the major German forces which formed a line about halfway between Naples and Rome. The idea was to get behind them and break through their line and then fight on to capture Rome. The landing was made with only two divisions. And the first assault met only light German resistance. But then the Germans reinforced and stopped the Allies. Both sides reinforced. The weather turned rainy and the battle was fought in mud. It was only after the weather cleared that the Allies broke the deadlock.



10,000 Ton (CL 55 Cleveland) Scale: 1/16"=1'



Aircraft Carrier Attack 1/16"=1'

Figure 1-9. Examples of World War II Ships

Before the Allies had won Anzio, the United States losses alone were 5,000 men and 20 ships. On 4 June 1944 the Allies reached and entered Rome. The Nazis had pulled out. This was two days before the great Allied invasion of Normandy.

OPERATION OVERLORD AND D-DAY IN NORMANDY

** Hitler tried to defend the long coast of France by heavy fortifications, mined beaches and readily movable striking forces but his preparations were not enough to stop the invasion. Operation Overlord came on 6 June 1944. **

Hitler expected an Allied invasion of his conquered Europe. But he did not know exactly where it would occur and he had 3000 miles of coastline to cover--all the way from Holland around the coasts of France to Italy. He decided, based on military intelligence, that the attack would come across the English Channel to the coast of France. But even if the attack did come to France, no one could be sure of exactly where. Field Marshall Von Rundstedt, one of Hitler's leading commanders, felt the attack would come across the narrowest part of the Channel, between Calais and Dieppe. But Hitler felt differently. He had a premonition that the attack would come to Normandy. He therefore decided to build up defenses along the long coast of France. He ordered a great fortification effort called the "Atlantic Wall" to be built. In short, he ordered that the beach be turned into a concrete and steel wall, a fort, protected by thousands of mines and obstacles in the offshore waters. He ordered the emplacement of hundreds of guns on land so that any landing position could be showered with bullets. Rommel felt that wherever the allied attack came, it would have to be repelled on the beach. And during the last few months before the invasion he had come to agree with Hitler about Normandy. As the executive in charge of the forces on the Channel coast, he ordered the construction of more underwater obstacles, bombproof shelters, and mine fields. Rommel had only one Panzer division at his disposal in Normandy. He put this on the beach and was able to check the enemy there on D-Day. He pleaded for another division but his request was denied. In addition to the beach defense, Field Marshall Von Rundstedt organized inland divisions which could move swiftly in delivering a powerful counter offensive to destroy the Allies after they had landed.

In the face of all Hitler's preparations, the Allies invaded Normandy beach. Hitler's strange premonition had been right. Commanded by General Eisenhower, the invasion of Normandy was the greatest amphibious operation in all history. Its mission was enormous: to crush the German Army and liberate France.

To prepare for the actual invasion, Eisenhower conceived a plan to weaken the German position. His plan had two parts. The first part was an all out air attack against Germany. He wanted to destroy the German Air Force and any factories manufacturing aircraft. It worked. By April 1944, the Allies knew they would have a 30:1 advantage in the air over Normandy.

The second part of the plan was to hit French railroad yards, bridges, trains and tracks in order to cripple any troop movement by rail in France. It worked. When the invasion came, transportation was so crippled, German troops had to get to the front on foot. Some had to ride bicycles. Eisenhower's two-pronged air attack prepared the way for the Allied amphibious troops.

The Allies also had to prepare for the difficult job of landing on the heavily fortified beaches. The landing operation took extremely careful planning. The Allies wanted to come in when the tides were just right. They selected one hour after low tide for the first wave of landing boats. In this way the tide would be rising just as the boats came in and they could unload the troops, retract their landing ramps and get out without becoming stranded. Also, as each wave of landing craft came in, the troops would have less and less beach to cross. Finally, at this tide, the obstacles placed in the water as part of Hitler's preparation could be more easily seen and therefore more easily avoided or cleared away.

The Allies also prepared for the harbor and supply problems they would encounter after they established a beachhead. The Atlantic waters off Normandy were very rough because of the unusually stormy weather (figure 1-10). Without harbors, it would be nearly impossible to land supplies. The British figured out a way to make portable harbors, made partly of old ships and partly of concrete. They looked like giant floating picture frames. These were floated across the English Channel and sunk in long lines along the beaches far offshore. They broke the rough waters. These gigantic artificial harbors called mulberries acted as shelters so supplies could be unloaded off the larger ships until the Allied troops could secure the port city of Cherbourg and its harbor. Once Cherbourg was taken, the Allies would have a place that could efficiently take in all the supplies needed for the rest of the invasion.

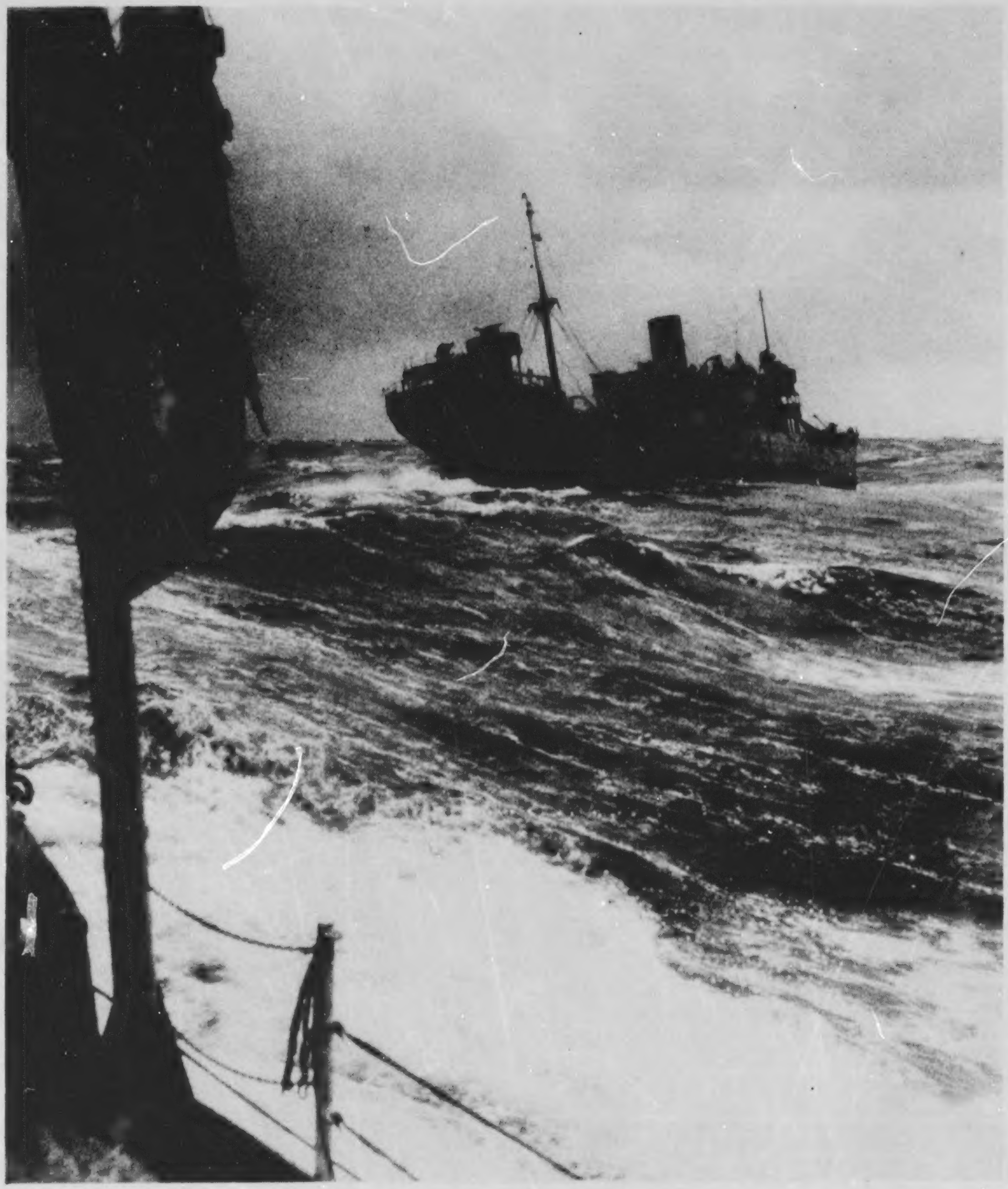


Figure 1-10. SS Coulmore in an Atlantic Storm on 20 May 1943

The actual landings took place on 6 June 1944 on five beaches. They were located between the Cotentin (Cherbourg) Peninsula and the Orne River mouth near the city of Caen (figure 1-11). The Americans landed at Omaha (figure 1-12) and Utah beaches. The British landed at Gold, Juno, and Sword beaches. The hardest and most bloody landing was at Omaha beach. This beach was six miles long and there were more German troops here than on the other beaches. The waters were filled with obstacles and Navy teams had to blast channels through. The beach was wider and the approach steeper and better defended. The ground troops were being cut to pieces. Admiral Bryant ordered his offshore destroyers to move in closer in order to give better fire support to the ground troops. Again cooperation among the combined forces worked.

The troops landed and established their beachhead. They expanded to cut off Cherbourg. The battle for Cherbourg went on with U.S. battleships, cruisers and destroyers getting into place by 25 June and shelling the port. The Germans resisted heavily but by 26 June the combined effect of naval bombardment and Army penetration forced Cherbourg to surrender. In two weeks, the port had been repaired well enough to receive Allied supplies.

The Allies now continued the invasion of Northern France. General Patton's U.S. Third Army swept through northern France, capturing 50,000 German troops. French resistance fighters rose up to help the Allies. By 24 Aug., the Allies captured Paris and General Eisenhower took command of the Allied ground forces in Europe.

It is very hard to picture the enormous size of the invasion. Altogether in the first 30 days, 929,000 troops, 586,000 tons of supplies and 177,000 vehicles were landed by the Allies on Normandy. 10,000 Allied aircraft (figure 1-13) flew to keep the German troops back away from the beaches. 400 mine sweepers worked to clear the sea lanes in the English Channel so that Allied troops could approach. As a result of these combined Allied efforts, by 4 July 1944, 1,000,000 troops had landed in France. The invasion of Europe was to continue until the Axis was defeated.

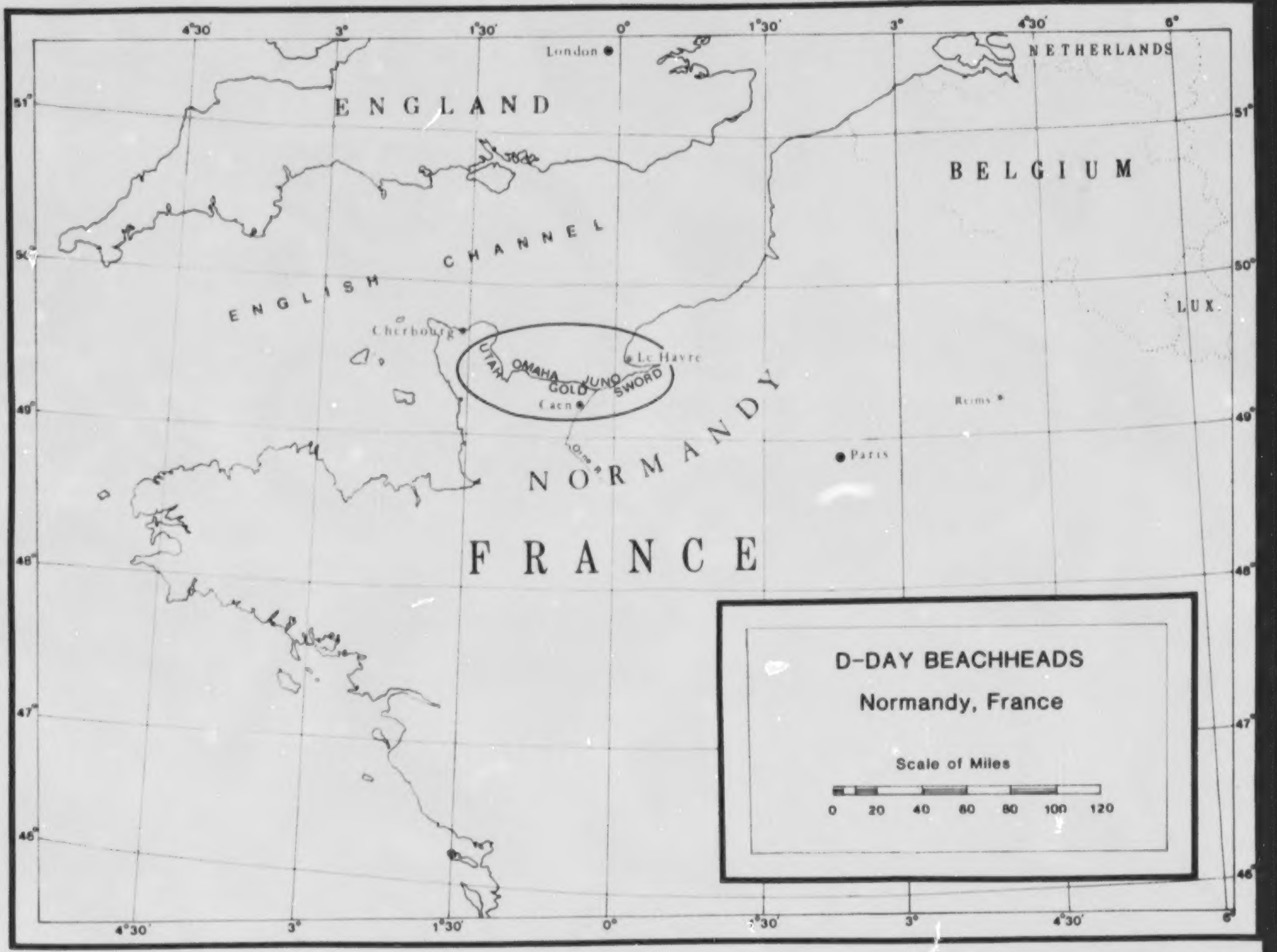


Figure 1-11. D-Day Beachheads, Normandy, France

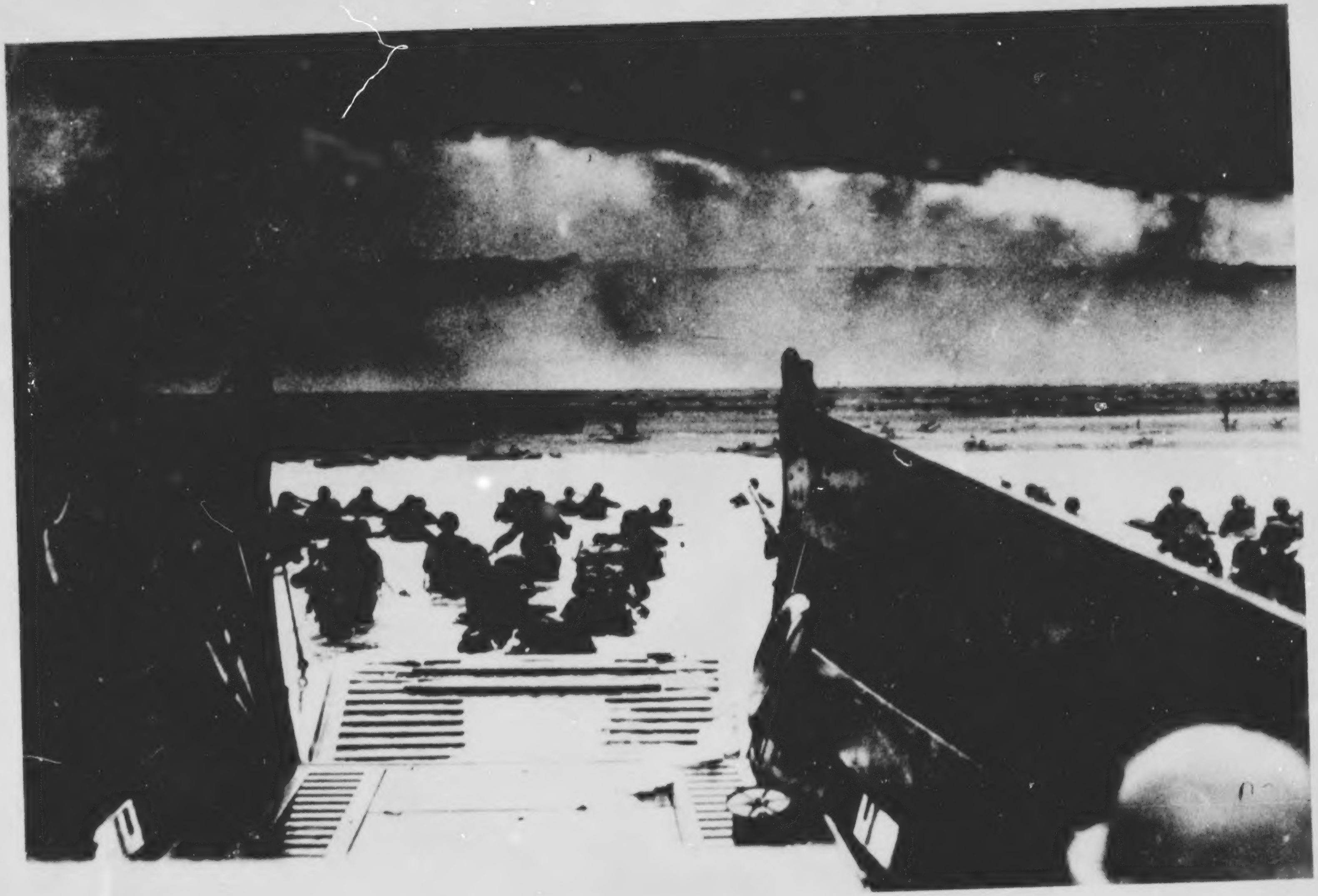
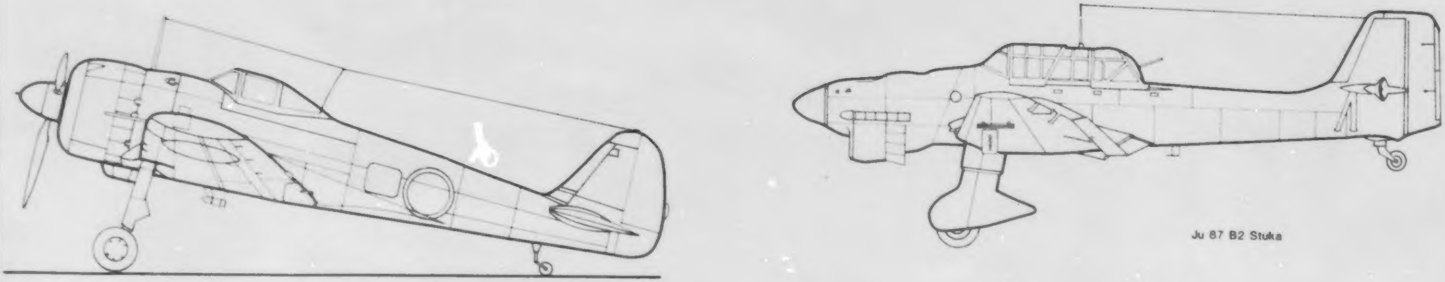
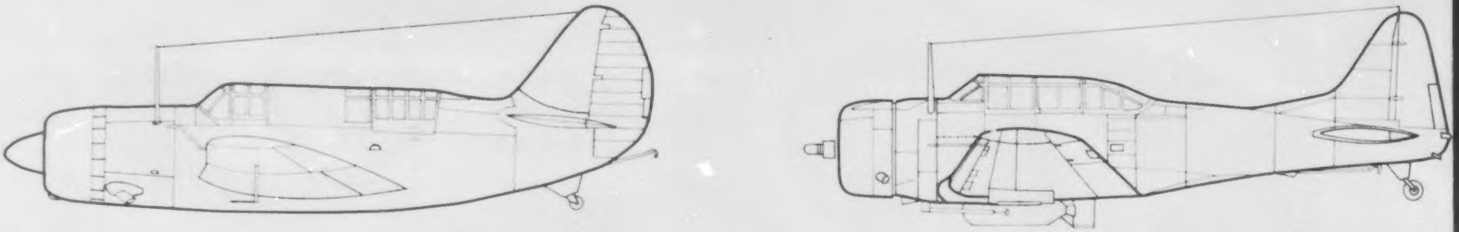


Figure 1-12. Army Troops Land on "Omaha" Beach
Normandy Invasion, June 1944



Nakajima Ki-43 Peregrine Falcon

Ju 87 B2 Stuka



Curtiss SB2C Helldiver

Douglas SBD-5 Dauntless

Figure 1-13. Examples World War II Planes

OPERATION ANVIL: INVASION OF SOUTHERN FRANCE

** The only other invasion in Europe took place on the French Riviera at Marseille. **

One more invasion took place in Europe. Operation Anvil took place on 15 Aug. on the French Riviera near Marseille. Its objectives were (1) to gain another port for supplies and (2) to pull German forces away from the major beaches in Normandy. It was successful and in two weeks the Allies had captured the port of Marseille, the Naval base at Toulon and the Riviera cities of Nice and Cannes. The Allies then pushed north and by 12 Sept. met Patton's Third Army at Dijon. By this time, Belgium, Luxembourg and most of France had been freed.

GERMANY IS DEFEATED

** The "Battle of the Bulge" in Belgium was the last German offensive. **

The invasion pushed the Germans back through France and into Belgium. On 16 Dec. the German General Von Rundstedt tried a major countermove in the Ardennes area of Belgium. In history this is called the Battle of the Bulge. Eleven days later, after fierce fighting, the Germans broke and ran. This was the last German offensive.

The Allied armies kept pressing toward Germany. American, British, French and Canadian troops pushed in on the Western and Italian fronts; the Russian troops pushed in on the Eastern front. By March, Bradley's armies reached the Rhine River in Germany. They crossed it on Navy landing craft that had been carried across Belgium in trucks and on railroad cars.

At about the same time the Russian Army was pushing in from the east. On 25 April 1945, the United States and Russian forces met at the Elbe river; Germany had been cut in half from west to east.

On 7 May 1945, the war ended in Europe. Hitler was dead; Mussolini was dead. The remaining leaders of the German Army signed an unconditional surrender at Eisenhower's headquarters in Reims, France. After more than five bloody years, World War II was over in Europe.

MULTIPLE CHOICE QUESTIONS:

1. The Allies decided to invade North Africa because:
   a. the Germans were increasing strength there and were getting dangerously close to Suez.
   b. Britain was getting the upper hand over Field Marshal Rommel and an invasion force would reinforce the effort.
   c. a secured Africa was the quickest route to an invasion of the German mainland.

2. The invasion plan for North Africa was called:
   a. Operation Vichy.
   b. Operation Neptune.
   c. Operation Torch.

3. The main worry in the invasion of North Africa was:
   a. how the Italian troops would respond.
   b. how the Vichy French Forces would react.
   c. the rough waters off the coast of Algeria.

4. In winter 1942-43 during the Battle of Stalingrad:
   a. the Germans defeated the Russians.
   b. the Russians defeated the Germans.
   c. the British withdrew their Sixth Army.

5. The major participants at the Casablanca Conference were:
   a. Stalin and Roosevelt.
   b. Roosevelt and Churchill.
   c. Churchill and Stalin.

6. The invasion of Italy was:
   a. started at Anzio.
   b. a combined effort by British and American forces.
   c. an American operation.

7. The "Atlantic Wall" was:
   a. a nine foot high wall built on the coast of England to provide protection from German attack.
   b. Hitler's fortification attempts to stop a successful allied invasion of Europe.
   c. Hitler's inland line of defense in France and Belgium.

8. "Mulberries" were:
   a. depth charge weapons used in anti-submarine warfare.
   b. portable harbors constructed out of concrete and old ships.
   c. code names for the beaches at Normandy.

9. Cherbourg was particularly important to the allies because:

   a. the Germans had large stores of oil located there.
   b. it was needed as a harbor to receive the allied supplies that would be pouring into France.
   c. the airfield there was crucial to support the later advances in southern France.

10. Operation Anvil was the name for:

   a. the attack on Belgium.
   b. the invasion of southern France near Marseilles.
   c. Von Rundstedt's last major offensive against the allies in Western Europe.

TRUE OR FALSE QUESTIONS:

T F

1. In 1942, the American command wanted to make a direct amphibious assault on Europe, and Churchill agreed. ____ ____

2. Operation Torch involved three separate forces. ____ ____

3. The allies' goal in Operation Torch was to take Morocco and Algeria and clear the Germans out of the rest of North Africa. ____ ____

4. The Sicilian compaign lasted over six months. ____ ____

5. The landing at Anzio in Italy was done to leapfrog over the major German forces who were between Naples and Rome. ____ ____

6. Mines were not an important German weapon during the invasion of Normandy. ____ ____

7. Part of Eisenhower's pre-invasion plan at Normandy was to use air power to cripple German transportation in France. ____ ____

8. The invasion of Normandy was to occur at high tide so that there would be no danger of the landing craft being stranded on the beach. ____ ____

9. The most resistance at Normandy occurred on Juno and Sword beaches. ____ ____

10. The last German offensive occurred in France and was called the Battle of the Bulge. ____ ____

VOCABULARY SKILLS:

Using the following vocabulary words, complete the sentences below. There is only one correct, appropriate word for each blank space.

theater: The whole land, sea, and air area that is or may be involved directly in a war's operations.

beachhead: A foothold area on an enemy's shore that is occupied to make further landing of troops and supplies possible.

retract: to pull or draw back.

obstacle: an object that is in the way.

enormous: great size; great number.

1. After delivering troops on beaches at Normandy, the landing craft would ________________ its ramps and return to pick up another load of troops.
2. One of the major difficulties of the allied landing craft was the number of ______________(s) placed in the offshore waters by the enemy.
3. The resistance put up by German troops at Anzio was ______________.
4. After establishing ____________(s), the allied troops expanded operations to cut off the port city of Cherbourg.
5. Operation Anvil was the only other invasion which took place in the European ______________.

BRAIN TEASERS:

1. Can you find out why the Battle of Stalingrad lasted so long? Did weather conditions have anything to do with its outcome?
2. The invasion of Normandy was code named Operation Overlord. What is there about this invasion that makes the code name seem appropriate?
3. The invasion of Normandy depended on cooperation between the allies. Try to imagine some of the difficulties that must have been involved in such a large cooperative effort.

IN THE PACIFIC BEFORE MIDWAY: ON THE DEFENSIVE

** Immediately after Pearl Harbor (7 Dec. 1941), the Japanese Navy moved south seizing more and more bases. In only five months, they secured their major objectives: unlimited oil, natural resources and a protective chain of island bases. **

Immediately following the attack on Pearl Harbor (7 Dec. 1941) the Allies made plans for the war against Japan in the Pacific. When the newly-appointed CINCPAC, Admiral Nimitz, assumed command on 31 Dec. 1941, the Japanese had already taken Guam, Wake Island, the Philippines, and the Malayas. The Navy's job, under Admiral Nimitz, was to hold the line against the Japanese. This imaginary battleline was drawn about midway in the Pacific. Above all else, Nimitz was to protect the sea lanes to Australia. But this job would be difficult to carry out because much of the U.S. Pacific Fleet was now destroyed. For all practical purposes, the U. S. Navy had no way to set up and hold a long battle line.

The Japanese Navy, on the other hand, was powerful. It was almost free to proceed south toward its main objective, the Dutch East Indies, and even beyond to the shores of Australia. The Japanese moved south capturing islands throughout the Philippines, establishing air support for themselves, and then going on to the next island objective.

By mid December, the Japanese landed near the oil fields of Borneo. Then they moved toward Java, the main island of the Indies. Java was the real prize because it was so rich in natural resources.

The remains of a very small Allied fleet commanded by Dutch Admiral Karl Doorman sailed to try and defend Java. The fleet consisted of the damaged cruiser Houston, 1 British heavy cruiser, 2 Dutch light cruisers, 1 Australian cruiser and 11 assorted destroyers. They engaged in battle on 27 Feb. with 14 destroyers and 4 cruisers under the command of Rear Admiral Takeo Takagi, convoying a large amphibious force. The Japanese had all the land based and carrier cover they needed. The bilingual allied fleet lacked a common language for rapid communication, common signal flags and code books, and as a result were unable to make fast, tactical moves.

After a three-day battle, the Japanese had completely destroyed the Allied fleet. Admiral Doorman went down with his flagship, fighting to the end. Only four American destroyers escaped. They had left the column before the battle was over after they had fired all of their torpedoes and used almost all of their fuel. By 9 March the island of Java surrendered to the Japanese.

By the end of March, the rich East Indies were in Japanese hands. And as you know, by April, Bataan and Corregidor had fallen. And so by April the Japanese had achieved all their objectives; unlimited oil, natural resources, and a tight chain of protective island bases.

THE JAPANESE DEFENSE LINE

** The Japanese established a network of island bases throughout the Pacific. **

A main part of the Japanese strategy in the Pacific was to set up a long defensive chain of bases. This line or chain was to run from Rangoon in the Indian Ocean, including all the Dutch East Indies, all northern New Guinea on the South, and extending to include Rabaul on New Britain and Kavieng on New Ireland in the southeast (figure 1-14). It then crossed the Pacific northward to Wake, Guam, and the British Gilbert Islands. On the northern border the line was protected by the Kurile Islands (from which Japan initiated the attack on Pearl Harbor). The only weak spot in this defense line was Midway Island, almost in the center of the Pacific.

The Japanese planned to use these bases to protect their rich East Indies holdings. But she also planned to use them as strongholds from which to defeat Allied reinforcements coming into the Pacific. From these bases Japan also planned to organize even further conquests. Finally, the Japanese believed that such strength would discourage further American attempts to oppose the Japanese in the Pacific and force the American Congress to accept a compromise peace, agreeing to let the Japanese keep all their possessions in Southeast Asia and the Indies.

This grand plan was defeated by Admiral Chester Nimitz and the U. S. Navy. After Pearl Harbor, he knew the Allies' forces were too weak for any all out battles so he created a plan of hit-and-run to confuse and embarrass the Japanese Command.

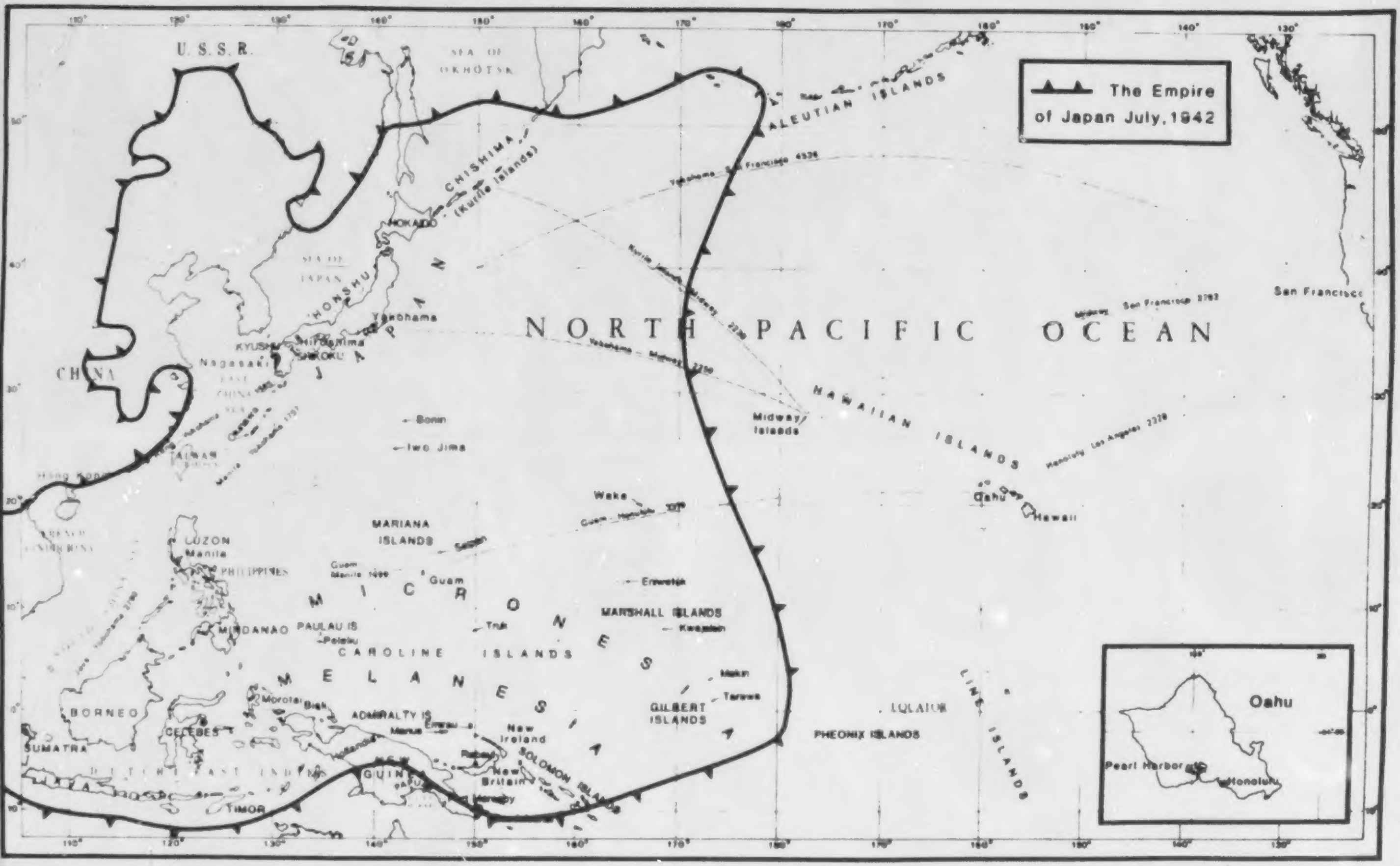


Figure 1-14. The Japanese Defense Line

The aircraft carriers, spared at Pearl Harbor, were chosen for the job. Forces from the carriers, under the command of Admiral Halsey, hit at widely spread out Japanese bases. The most shocking raid to the Japanese took place on 18 April 1942. You could accurately call the raid a combined Army Air Corps and Navy effort. The carrier Hornet, 650 miles from Japan, launched 16 B-25 Army bombers. Under a screening cover of bad weather, the carrier had planned to get within four or five hundred miles of Tokyo before launching the planes, but they ran into two small Japanese patrol vessels while they were still some 700 miles from Tokyo. They decided to launch the B-25's immediately, fearing that the patrol boats had given the alarm. The bombers, led by Colonel Doolittle, hit targets in several Japanese cities. The Japanese were as surprised as we had been at Pearl Harbor. Not one American plane was lost over Japan. Because the planes did not have enough gas to fly back to the carrier they flew on to China. They had originally planned to land on Chinese airfields but there was a mix-up in communications due to the early launch and the airfields were dark. They cruised around until their gasoline was exhausted, then either crash-landed in the surf or bailed out and let their planes go down in the waters off China. Of the eighty fliers on the mission, seventy-one eventually returned safely to the United States. However, two pilots who fell into Japanese hands were beheaded.

This "little Pearl Harbor" did almost no damage to the Japanese. But it shocked them and made them realize that their boast -- "Japan could never be attacked" -- was not true. The Japanese commanders did not know where the bombers came from. But they did know they wanted to prevent bombers from surprising them again. As a result, they assigned hundreds of planes to stay and defend Tokyo.

Most important of all, the Japanese Command decided to take more territories, especially Midway Island. They felt that if they secured Midway in the Central Pacific and destroyed the forces there, the Americans would not be able to send surprise planes again. They also felt that an attack on Midway and a few other positions would not be enough.

And so the Japanese stretched their plans even farther. They decided to move also into the Coral Sea area to cut the Allied sea lanes to Australia. They also decided to make a two-pronged attack into the Solomon Islands and Port Moresby in New Guinea. Japan decided to reach out in many directions at once. The Japanese commanders had decided to break the Allied forces in the Pacific once and for all.

Admiral Nimitz knew about the plans because the Japanese secret code had been broken. He had plans of his own. He ordered Task Force 17, a two-carrier group (Lexington and Yorktown) under Rear Admiral Fletcher, to go to the Coral Sea and be waiting there when the Japanese arrived.

BATTLE OF THE CORAL SEA

** The Battle of the Coral Sea turned into the first great Naval battle between aircraft carriers. It was also the first time that the Japanese Navy was turned back in the Pacific. **

When the Japanese carrier forces arrived, the American carriers, Lexington and Yorktown, were there to meet them. So were three cruisers and a few destroyers. Here in the quiet Coral Sea the first great naval battle between aircraft carriers took place. This was the first naval battle in which no ship on either side ever actually saw their opponent's ships.

Perhaps because it was the first great carrier battle, the action in the Coral Sea was filled with mistakes. Some were funny; most were not. For example, on 7 May, the two Japanese carriers Shokaku and Zuikaku sent out a search party looking for the enemy they were sure was in the Coral Sea. The planes saw Admiral Fletcher's retiring fueling ships, an oiler and a destroyer. The Japanese planes mistakenly reported the oiler and destroyer to be a carrier and a cruiser. Japanese Admiral Takagi ordered an all-out bombing attack and sank both ships. The American carriers themselves were never touched. One funny anecdote says that in the gathering gloom of the evening of 7 May, several Japanese planes mistook the Lexington for their own carrier. They joined up with the American planes circling for a landing. When one of the American destroyers noticed them and opened fire, they left in a big hurry!

The Americans made mistakes too. American planes reported seeing "two carriers and four heavy cruisers." Admiral Fletcher thought this must be Takagi's Strike Force and sent his planes to attack. When the planes were already in the air it was discovered that the report should have been "two heavy cruisers and two destroyers." But the planes luckily met a light Japanese carrier, Shoho, and sunk her in 10 minutes.

Fighting continued on 7 May. But the great battle came on 8 May. On 8 May the two great carrier forces under the command of Admiral Fletcher and Takagi found one another and launched their attack waves. They were evenly matched.

During the long battle the Lexington was so badly hit she had to be abandoned. Later the Americans had to sink her. This was the most serious American loss.

But the Japanese Navy had been turned back for the first time in the Pacific. And the upcoming Japanese invasion forces of Midway would be three carriers short. The American carrier Yorktown, on the other hand, would be ready!

THE BATTLE OF MIDWAY

** The Battle of Midway was the turning point in the Pacific War. It resulted in the Japanese losing four carriers, a cruiser and most important, the best Japanese carrier pilots. **

Admiral Yamamoto had one major goal in attacking Midway Island; to draw out and destroy the U. S. Pacific Fleet now that it was weakest. Yamamoto knew that if he and his mighty Combined Fleet could do this Japan could take any position in the Pacific. Admiral Nimitz and the sailors of the small Pacific Fleet did not let this happen.

Yamamoto had a large portion of the Japanese Navy with him. He had 162 warships and many others not counting small patrol crafts. Among the huge fleet were 11 battleships, 8 carriers, 23 cruisers and 65 destroyers. Two Japanese carriers were left behind. One, the Shokaku, had been damaged in the Coral Sea, and the other, the Zuikaku, was kept in port because replacements for the experienced air crews she had lost could not be trained in time. Admiral Nimitz had only 76 ships and one-third of these never got into the battle because they were too far away. He did have the carriers Hornet and Enterprise, which had raced back from the Coral Sea, and also the carrier Yorktown, which had been repaired in an amazing 48 hours instead of three months. This was a surprise for Yamamoto.

But Admiral Nimitz had strong, uncountable weapons. First, he had superior officers. He had Rear Admiral Fletcher on the Yorktown. He also had Rear Admiral A. Spruance who was in command now of Halsey's Task Force 16. Spruance had two carriers under him -- the Enterprise and the Hornet. Each carrier had an excellent commanding officer.

But the greatest weapon of all was surprise. The Japanese did not realize their code had been broken. As a result, Yamamoto created an elaborate battle plan, dividing his Fleet into four main forces subdivided into 10 subgroups and stretched out from the Aleutian Islands to Midway. The Northern Area Fleet hit the Aleutian Islands on 3,4,6,7 June 1942. This attack was mainly diversionary but, of course, failed to divert American attention away from Midway. Japan's Midway occupation force (Second Fleet) ran into trouble under attack from an American submarine. In the process of dodging torpedoes the cruisers Mogami and Mikuma collided on 4 June. On 6 June, the injured Mikuma was sunk by Spruance.

The third force was the battleships' main body. Most important was the final force, the striking force, the First Air Fleet.

The First Air Fleet (Admiral Nagumo's striking force) was the combined Fleet's strongest arm. It was the main strike force on Midway. It was built around four carriers; the Akagi, Kaga, Hiryu and Soryu. They approached Midway under a heavy cloud cover. Nagumo's force was attacked eight different times by American torpedo planes, bombers and submarines. All the torpedoes missed. Nagumo was not hit once. At this time the American torpedoes were inaccurate.

But Nagumo's luck failed. He had already launched 108 planes on Midway. He was prepared, on their return, to rearm them with bombs and send them off again for a second raid. While waiting, he got word of the American carrier task force that should not have been there -- but was. He decided to get planes ready with torpedoes to hit the carriers. He also decided to let his returning planes land before launching the torpedo planes. The bombs all prepared for the second Midway attack were stored on deck. As Nagumo was turning his carriers into the wind ready to launch his torpedo planes against the American carriers, American planes from the Enterprise and Yorktown came in. Spruance had figured out that Nagumo might change his tactics so Spruance launched his own attack planes. The planes were high altitude dive bombers. American bombs hit the Soryu, Kaga, and Akagi. The bombs on the decks exploded and the ships burned up with most of their planes still on the decks.

One carrier, the Hiryu, escaped and sent up her own dive bombers which found and hit the Yorktown. Fletcher had to abandon the ship and turn command of the fleet over to Admiral Spruance. The Yorktown's search planes, however, found the Hiryu and reported her position. At Spruance's orders, Enterprise dive bombers quickly destroyed the Hiryu. As a result, Admiral Yamamoto realized he was now without any carriers to protect his main warships.

The Battle of Midway was a gigantic Japanese defeat and was the turning point in the Pacific War. The Japanese lost (1) their four giant carriers, (2) a large cruiser (figure 1-15), and, perhaps more importantly, (3) their main body of ace pilots. Without superior pilots, the Japanese air efforts in the Pacific would suffer terribly. As American training programs for pilots would grow stronger later on in the war, Japanese programs would grow weaker.

Only one small part of the Japanese plan had succeeded; the Northern Area Fleet had taken the islands of Kiska and Attu in the Aleutians. As a result of the Midway defeat, the Japanese cancelled plans to conquer new positions in the Pacific. The tiny atoll group was, indeed, properly named, for the contest marked a dividing line in strategy, if not in time.

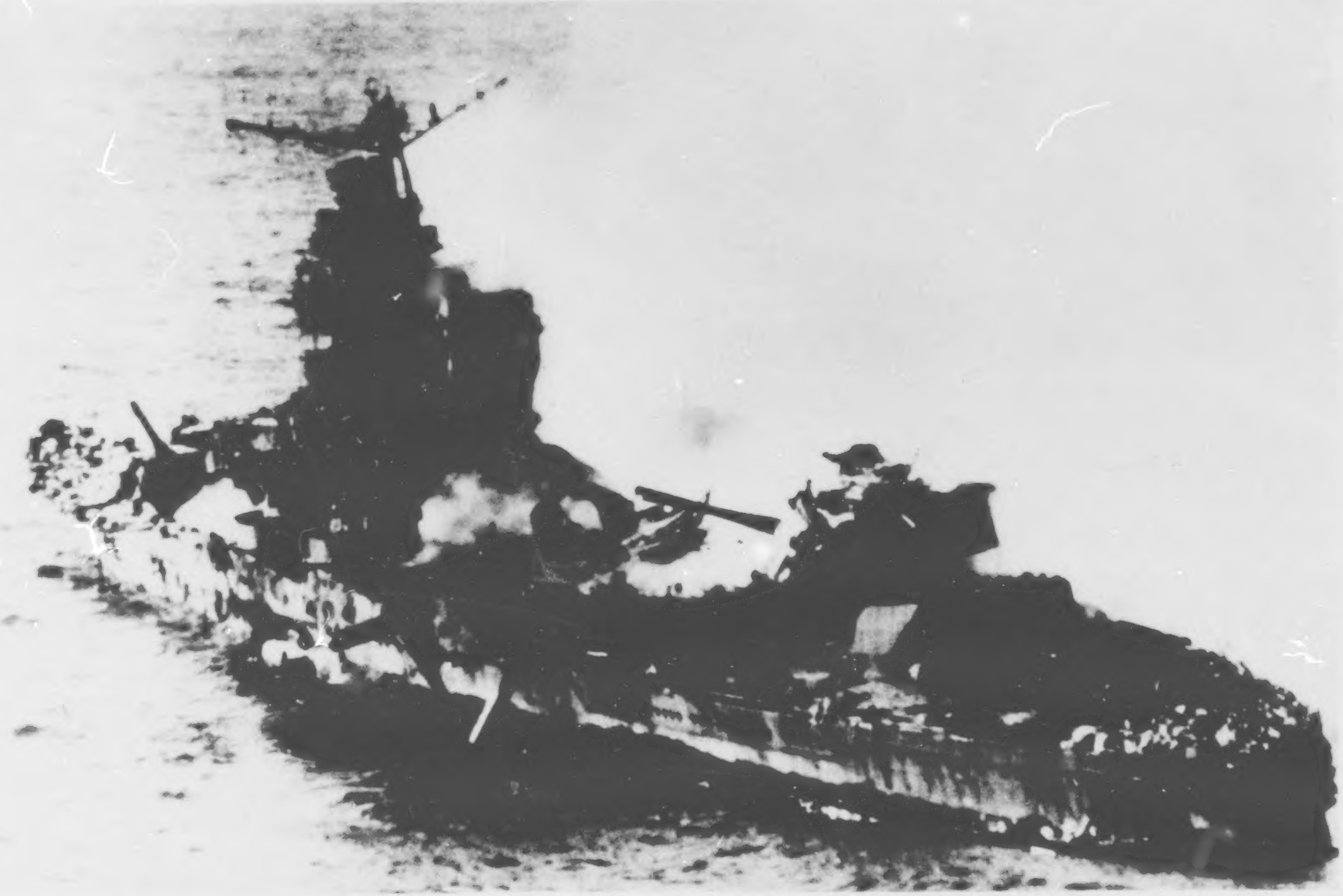


Figure 1-15. Japanese Heavy Cruiser After Attack, Battle of Midway Island

MULTIPLE CHOICE QUESTIONS:

1. After Pearl Harbor the Japanese:

   a. moved north to the Aleutian Islands.
   b. tried to negotiate a peace treaty with Britain.
   c. launched major attacks throughout the South Pacific.

2. At Midway the:

   a. American and Japanese Fleets were evenly matched.
   b. Japanese Fleet was far larger than the American.
   c. American Fleet was far larger than the Japanese.

3. The Japanese Defense Line was a:

   a. series of protective air bases established on the island of Honshu.
   b. long defensive chain of island bases in the Pacific, used mainly to protect Japan's conquest of the Dutch East Indies.
   c. complex of three fortresses established across Borneo.

4. The Battle of the Coral Sea was:

   a. mainly conducted by battleships.
   b. mainly conducted by aircraft.
   c. a Japanese victory because they sank two major American carriers, the Yorktown and the Enterprise.

5. Doolittle's raid on Japan was:

   a. an Army Air Corps operation.
   b. a Naval operation.
   c. a combined Army Air Corps and Naval operation.

6. To prepare for Midway, Admiral Yamamoto maintained the combined Japanese Fleet in:

   a. one force.
   b. two forces.
   c. four forces.

7. The major arm of the Japanese Fleet at Midway was the:

   a. Northern Area Fleet.
   b. Midway occupation force.
   c. First Air Fleet.

8. At Midway, the Japanese:

   a. retained their carrier and air superiority.
   b. lost two cruisers but maintained air superiority.
   c. lost their main body of fighter pilots.

TRUE OR FALSE QUESTIONS:

T F

1. The Japanese attack on the Aleutian Islands was successful. ____ ____

2. Java was a major Japanese objective because it was a strong military base. ____ ____

3. Rangoon, in the Indian Ocean, was part of the Japanese Defense Line. ____ ____

4. Midway was the one weak link in the Japanese Defense Line. ____ ____

5. Doolittle's air strike on Japan caused major physical damage to its cities. ____ ____

6. Admiral Nimitz was prepared for the Japanese assault in the Coral Sea because the Japanese secret code had been broken. ____ ____

7. American torpedo attacks on Nagumo's Striking Force at Midway were very successful. ____ ____

8. Admiral Karl Doorman was successful in defending Java. ____ ____

9. Admiral Nagumo's striking force was built around four battleships: Akagi, Kaga, Hiryu, and Soryu. ____ ____

10. After Pearl Harbor, Admiral Nimitz ordered an all out attack on Japanese bases in the Pacific. ____ ____

VOCABULARY SKILLS:

Using the following vocabulary words, complete the sentences below. There is only one correct, appropriate word for each blank space.

objective: goal or aim.

initiate: to begin; to start going.

compromise: to agree to make concessions.

accurate: free from error.

boast: brag.

elaborate: complicated by details.

diversion: an attack or pretended attack that draws the attention and force of an enemy from the point of the main operation.

1. The Japanese ____________ was to establish a powerful line of defensive bases.
2. It was from the Kurile Islands that Japan ____________d their attack on Pearl Harbor.
3. The Japanese believed the United States would ____________ in order to secure a quick peace.
4. American intelligence had ____________ information about Japanese battle plans.
5. After Colonel Doolittle's raid on Japan's mainland, the Japanese could never again ________ that "Japan could never be attacked."
6. Yamamoto's battle plan to attack Midway was _________.
7. The Northern Area Fleet was Japan's ____________ary force in the attack on Midway Island.

LOCATIONS IN THE PACIFIC:

From the following list supply the correct place, next to its appropriate description:

Midway

attempt to cut off sea lanes to Australia

Corregidor

Rabaul

Kiska

Borneo

Port Moresby

1. Battle of the Coral Sea.
2. located on New Britain, part of the Japanese chain of bases.
3. turning point in the Battle of the Pacific.
4. an island in the Aleutians.
5. large island rich in oil, captured by the Japanese.
6. after Doolittle's raid, one of the important targets the Japanese decided to destroy in order to break allied forces in the Pacific once and for all.
7. heavily fortified island near the Bataan Peninsula where allied troops made their last stand in the Philippines near the beginning of the war.

IN THE PACIFIC AFTER MIDWAY: ON THE OFFENSIVE

** After Midway, Americans realized the Japanese could be defeated in the Pacific. **

Midway marked the turning point in the Pacific War. The giant Japanese Navy had been defeated by Americans combining the use of intelligence information with the will to fight.

SOLOMON ISLANDS OPERATIONS

** After Midway, Guadalcanal in the Solomon Islands became the next major battle between the Japanese and the Allies in the Pacific. **

After Midway, the American command felt they were in a good position to take the offensive against the off-balance Japanese, perhaps for the first time. They decided the best place to attack would be in the Solomon Islands in order to break the Japanese perimeter closest to Australia.

The Japanese at the same time recognized a threat to their extended position and realized that their advance in the Pacific could be stopped. They decided to strengthen their advance positions (i.e., the positions in the Pacific farthest away from Japan and closest to the coast of Australia). These were the Solomon Islands.

And so the Solomon Islands became the site of the next major American-Japanese Pacific conflict. The Japanese began to build an air field on Guadalcanal Island. They planned to use the field to protect their troops as they completed their conquest of New Guinea. An American reconnaissance plane saw this and the American command realized that if the Japanese completed the field and positioned bombers there, the Solomons would be exceptionally difficult to secure. So Guadalcanal Island became the primary objective in the struggle for the Solomons.

The Marines landed on Guadalcanal 7 Aug. They also landed at nearby Tulagi. Japanese forces on Guadalcanal were weak and composed mainly of construction workers who fled into the jungle. By night of the first day, two Marine regiments with support units were ashore. The situation was different at Tulagi because the Japanese forces were stronger and were dug in. Yet on the second day 6,000 American Marines wiped out the Japanese resistance there.

The Japanese sent attack planes from their nearby base at Rabaul. These planes were repelled by the American carriers Saratoga, Wasp and Enterprise. But after the hard battle, the carriers withdrew because of fighter plane losses and because they needed to refuel.

Meanwhile, the Japanese were sending a major body of cruisers to the area to attack the Americans' amphibious ships. These cruisers were coming down "the slot," a sea passage down the middle of the Solomons from Rabaul (see map of the Pacific (figure 1-16)). The Japanese cruisers, under the command of Vice Admiral Gunichi Mikawa, surprised the American and Australian surface force off Savo Island in the Solomons.

These battles of Savo Island resulted in the worst defeat the U.S. Navy has ever suffered; 3 American and 1 Australian cruiser were sunk, another American cruiser and 2 destroyers were badly damaged, and 1,202 Marines, 550 soldiers and over 1,000 Allied sailors were killed.

With the carriers away and the amphibious forces nearly destroyed, 20,000 American Marines were left on Guadalcanal with limited supplies and limited support. It was very lucky that the Japanese ground forces were weak here. Because of this weakness, the Marines were able to capture the airstrip, later named Henderson Field, and set up a defense line. The Seabees finished the air field by August so planes were able to bring in supplies.

BATTLE FOR GUADALCANAL

** The battle for Guadalcanal lasted over six months with the Japanese continually reinforcing their troops. Both sides suffered heavy losses but by the end of the battle the Japanese had lost over 600 planes and their irreplaceable, experienced crews, thousands of troops and many major ships. After Guadalcanal the U.S. Navy was no longer on the defensive. **

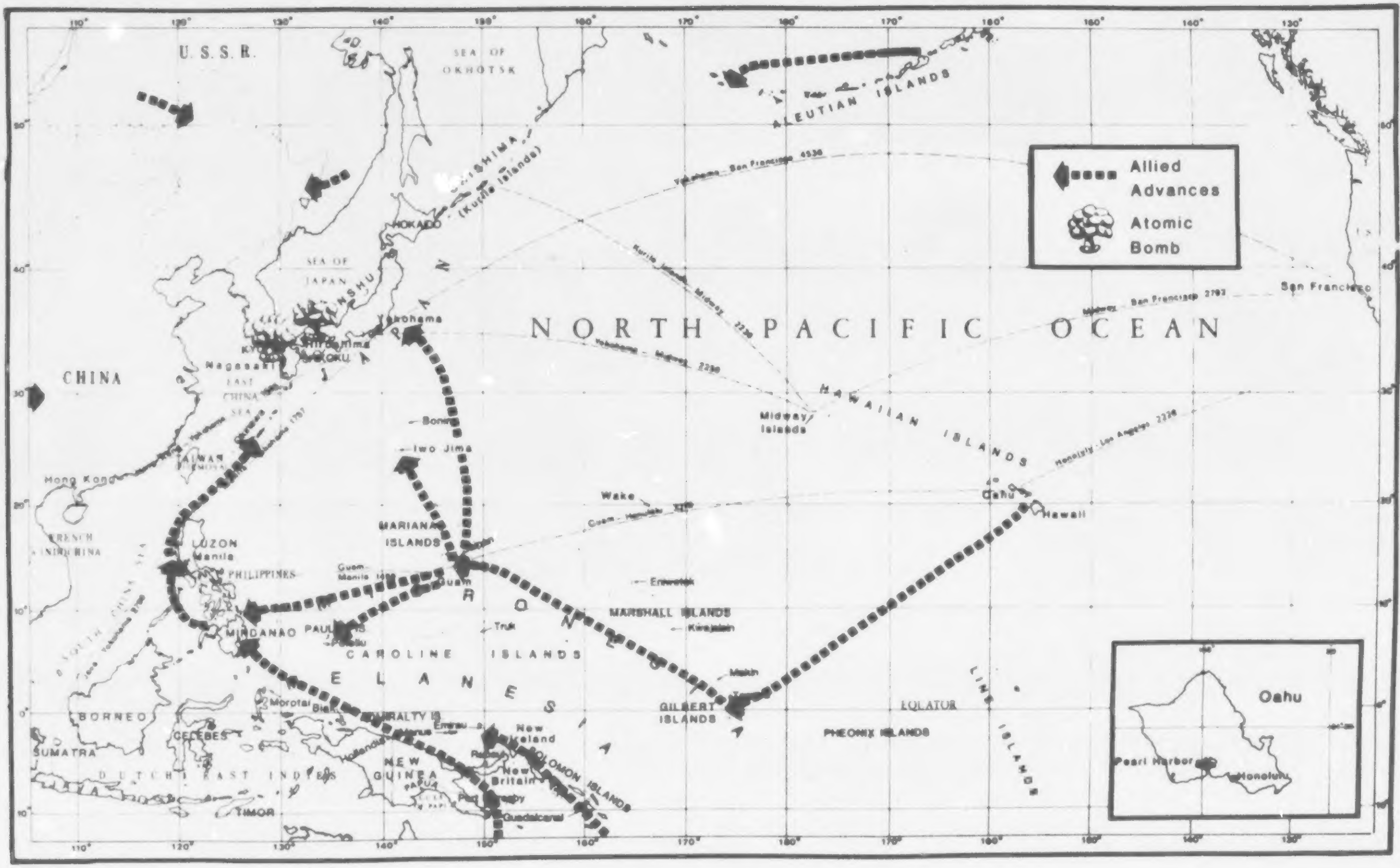


Figure 1-16. The Allied Advance in the Pacific After Pearl Harbor

The Japanese were amazed that the Americans had completed Henderson Field. They felt they could not stand by and let the Americans have a working airfield on Guadalcanal. So the Japanese began pouring troops into the area. They brought thousands of troops at night aboard fast transports and destroyers. They protected these with carriers, and heavily bombarded the Marine positions from the sea. The Americans even nicknamed this troop movement. They called it the "Tokyo Express." By 15 Oct., despite great losses inflicted by the U.S. Navy on the Japanese transports, 22,000 Japanese troops were ashore.

As the Japanese continued this massive effort to land troops, the American Navy continued their efforts to stop the Express. The naval battles were fierce, with the Japanese Combined Fleet inflicting heavy losses (figure 1-17). But the Marines on Guadalcanal held on, killing 10 enemy for every American death.

On 24 Oct. a major loss occurred when the U.S. Navy, during the Battle of the Santa Cruz Islands, lost the carrier Hornet. In addition, the carrier Enterprise was badly damaged. The significance of this loss was that it left no operational U.S. carriers in the Pacific. However, the Japanese also suffered severe damage.

The naval battle of Guadalcanal was now about to begin. The battle took place in three phases; 12-13 Nov., 13-14 Nov., and 14-15 Nov. But the most important event took place on 12 Nov. The Japanese were coming down the slot, bringing 11,000 troops aboard 11 transports.

This fleet was protected by destroyers, cruisers and two battle ships. On the night of 12 Nov., American and Japanese cruisers met and battled. Both suffered heavy losses. But the Japanese loss was heaviest. Besides their battleships, the Japanese lost 9,000 troops! Perhaps as important, during the ensuing battles, the Japanese were losing most of their carrier force. The Japanese had put almost all their best pilots on the carriers for this effort. They had also put on their best fighter instructors. Almost all were killed by the time the battle for Guadalcanal was over. Strategically, the Japanese had failed in their plan to recapture Guadalcanal. But much hard fighting was yet to take place before either side could claim a decisive victory.

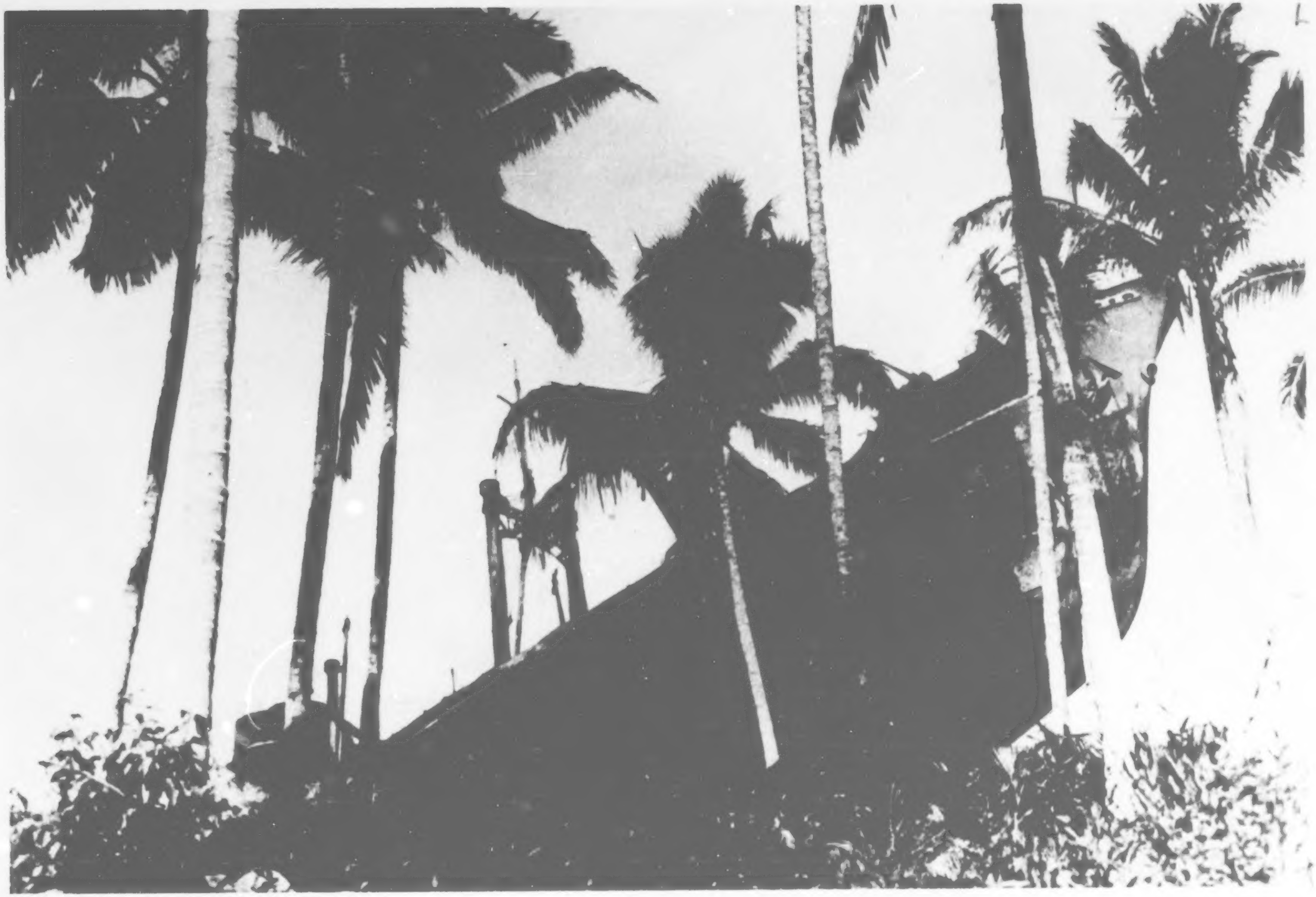


Figure 1-17. Japanese Transport KYUSYU MARU, Beached and Sunk at Guadalcanal, October 1942

On shore, the Marines continued to fight. The Japanese were driven into the jungle. From 1-7 Feb., the Japanese skillfully managed to evacuate 13,000 troops.

NEW GUINEA

** The Battle for New Guinea was mainly a land war. **

At about the same time Americans were fighting for Guadalcanal, the Allies were fighting a land war to win New Guinea. Neither side used major naval forces in the action because they feared the uncharted waters, the number of enemy air fields held by the other side, and the heavy Navy involvement near Guadalcanal. As a result, the land casualties were very high (almost twice those at Guadalcanal), and the fighting was slow. Led by General Douglas MacArthur, it took the Allies from April to August 1944, with continual reinforcement from Australia, to eventually overcome the Japanese and win Papua and all of New Guinea to the west of Rabaul. The next step was to win Rabaul, Japan's major base in the Southwest Pacific.

THE STRATEGY OF 1943: CONTINUOUS PRESSURE

** The Allies met in 1943 to construct an overall plan for the defeat of the Japanese in the Pacific. **

After the victories at Guadalcanal and New Guinea, the Allied leaders decided to allocate more military resources to the Pacific. They wanted to keep on the offensive. Because British and Chinese forces were unavailable, the defeat of the Japanese fell upon the shoulders of the United States forces assisted by Australia and New Zealand when possible. They decided on a plan they thought would finally defeat the Japanese in the Pacific. It had four main parts:

1. eliminate the Japanese outposts in the Aleutian Islands.
2. add more submarine attacks on Japanese lines of communication from the Indies.

3. isolate Rabaul using MacArthur's forces and the South Pacific Naval forces and after the isolation, move westward along the northern coast of New Guinea.

4. use the Central Pacific naval forces under Nimitz to attack and capture the Japanese bases in Micronesia (to the West).

RECONQUEST OF ATTU AND KISKA

** By 15 Aug. 1943, the Americans had recaptured Attu and Kiska Islands in the Aleutians. **

The Japanese held Attu and Kiska in the freezing cold Aleutians. On 11 May the Allies attacked Attu. After two weeks of fighting, almost all the Japanese had been killed. But many Allies died too. Others suffered from bad frostbite because of poor clothing and footwear. Taking Attu was costly.

The Allies were more careful in preparing to attack Kiska. Training was better; clothing was better; advanced bombing took six weeks. A strange thing happened. During the fourth week of the bombing, Japanese cruisers and destroyers slipped in and evacuated the troops under the cover of fog. For three weeks the bombing had hit empty barracks. But by August, regardless of the clever Japanese escape, the Americans once again controlled the Aleutians.

SUBMARINE OPERATIONS IN THE PACIFIC

** The American submarine was the most effective weapon that the United States had in the Pacific. **

The submarine was the most effective weapon that the United States had in the Pacific. American submarines stopped the Japanese ships from returning to Japan. These ships were loaded down with the raw materials (rubber and oil) from the Indies that Japan needed to carry on the war. Dependent upon imports during peacetime, Japan was doubly so when dedicated to a war of conquest. There were many reasons why the submarines were so successful. One of the most important was their crews. All were volunteers. All were carefully trained. And all were deeply dedicated. In the "Silent Service", one out of seven submariners died. Personnel strength of the submarine operating forces averaged 14,750 officers and men. Fatalities during the war totaled 3,131 enlisted men and 374 officers.

In their attack on Pearl Harbor, although the Japanese were aware of our submarine base in Hawaii, they failed to damage the submarines, their supplies or facilities. On that day the submarines of the Pacific Fleet were widely dispersed: the fleet consisted of 22 submarines, 16 modern V-boats and 6 S-boats of older vintage, under the command of Rear Admiral Thomas Withers. Five subs in various stages of overhaul were at the base when the Japanese attacked and by that evening several of the subs were fueled and ready to go. The Japanese would soon regret that they had designated the submarine base and its facilities minor targets.

It is difficult to understand how the Japanese underestimated the undersea power of the United States. The German U-boat blockade of England in WW I had brought England to the brink of defeat. Again in WW II the Nazi Admiral Doenitz all but sank the United Kingdom. The similarity of England and Japan, both islands, should have been hard to overlook. Both Japan and Germany underestimated the industrial capacity of the United States. At the end of the war, the U. S. had 127 more submarines than in 1941, despite the loss of 52 operating submarines during the war.

After Pearl Harbor, when the Japanese subs did so poorly, the Japanese just did not value the subs. On that fateful morning, a Japanese midget sub was the first casualty. So they did not train men in anti-submarine warfare. Also their escort system was weak. In addition, it was easier for the American submarines to sink Japanese shipping in the Pacific than the Atlantic. The Pacific is a large ocean but it is not an open ocean like the Atlantic where convoys can follow any number of routes. Instead, the western Pacific is filled with islands and the possible supply routes are in narrow straits between these islands. The routes from the supply islands of Borneo, Sumatra and Java to Japan are often through narrow straits. Also, these routes are further restricted by reefs and shoals. These same reefs and shoals provided American submarines good places to hide. Lying in wait, the submarine crews could be sure that eventually the enemy merchant ships would pass.

By 1943 American scientists had learned to design (1) better, more accurate torpedoes and (2) submarines that were suited to action in the Pacific. The subs were larger (almost twice the size of the German U-boats used in the Atlantic) and able to carry more torpedoes and more fuel. This enabled them to stay out longer on patrols. They were capable of cruising for 75 days and could cover 10,000 or more miles at normal speeds without refueling. They ran on the surface as much as possible in order to charge the batteries they needed for power when submerged. The older, S-class submarines, nicknamed "pig boats" because of their crowded, dirty living conditions, served the U. S. well throughout the war.

Three warships in the United States Navy were twice awarded the Presidential Unit Citation. Two of the honored three were submarines: Guardfish, (Commanders T. B. Klakring and N. G. Ward) and Tang (Commander R. H. O'Kane). At the time the Tang went down, she had sunk 24 Japanese ships and made 22 rescues. Only one other submarine, Tautog, would sink more ships, and only one other submarine, Tigrone, would top her rescue score. Tang was sunk by her own torpedo 24 Oct. 1944, which malfunctioning, circled back to hit her. Tautog was one of those submarines in port when the Japanese attacked Pearl Harbor and survived the war having sunk 26 enemy ships.

As American submarines increased their attacks on Japanese merchants, the Japanese manufacturers became less able to continue their shipbuilding program. The raw materials were not getting home. They also grew less capable of producing needed weapons and were running short of precious fuel.

American submarines destroyed over 1,000,000 tons in Japanese merchant ships. They destroyed an additional 580,000 tons of Japanese naval ships (figure 1-18). Although the submarine force consisted of less than 2% of the Armed Forces, submarines sank about 55% of all Japanese shipping during the war years. The American submarine can truly be called the weapon that won the war for the United States in the Pacific.

RINGS AROUND RABAUL

** By March 1944, the Allies had surrounded the giant Japanese base of Rabaul. **

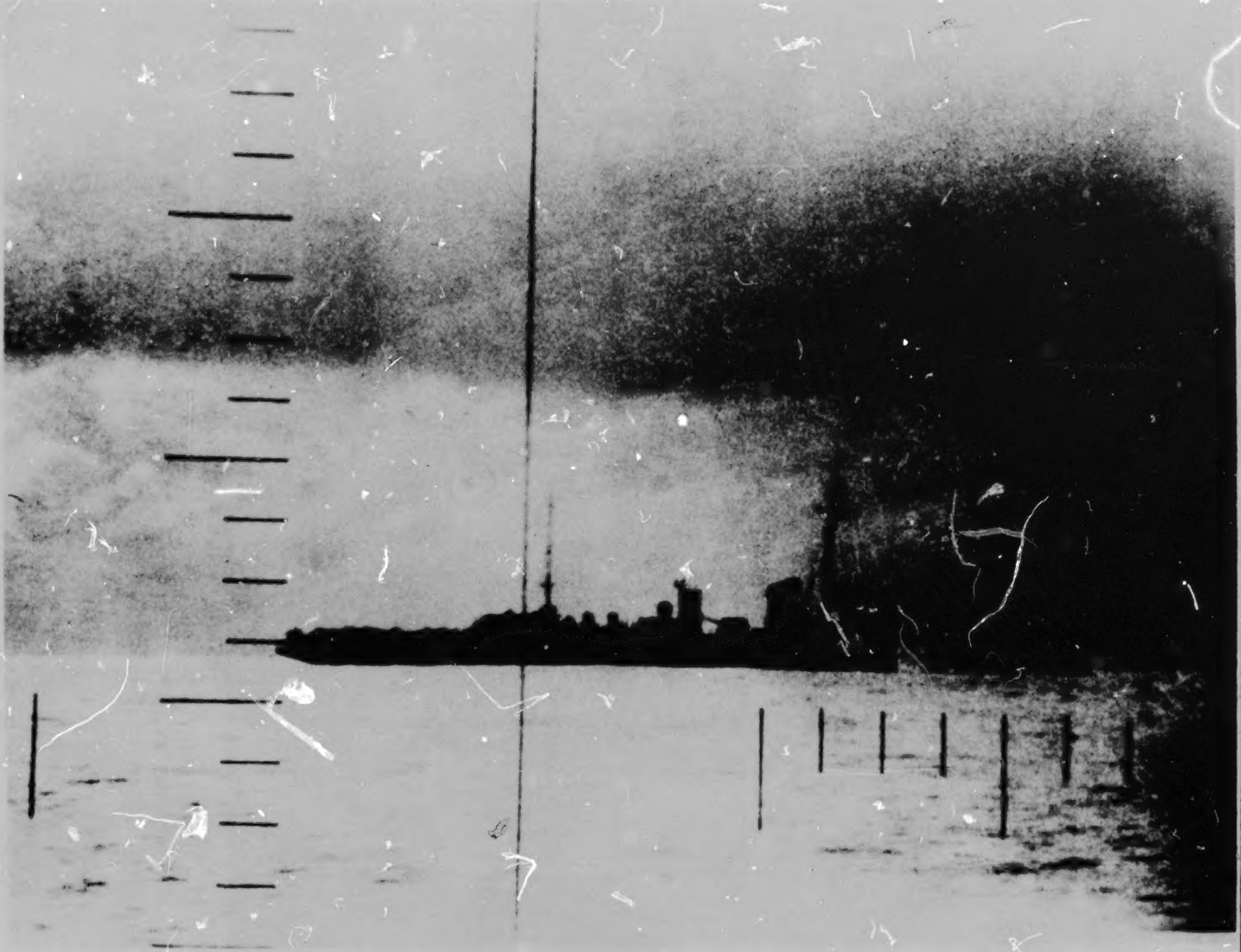


Figure 1-18. Japanese Patrol Boat Sunk by USS Seawolf, April 1943

In June 1943 Admiral Yamamoto, probably the most able of the Japanese naval command, was on his way to visit Japanese bases in the Solomon Islands. The Japanese had suffered severe losses in battles against American ships there and Yamamoto was making his visit to inspect bases and to boost troop morale. The Americans broke a code message ordering the Japanese bases to make themselves ready for an important visit, guessed correctly that the visit could only be a high-ranking officer, and sent up long-range fighters from Henderson Field. They intercepted Yamamoto's plane and shot it down. Yamamoto had hoped to raise the spirits of his troops by visiting them. Instead, his death was a severe loss to Japan's Navy during its 20 month attempt to defend the giant base of Rabaul. The Allies pushed toward Rabaul on two fronts; through the Solomons and on New Guinea.

In the attempt to take Rabaul, the U.S. Fleet fought over 15 major naval battles and made 17 invasions in the Solomons and Southwest Pacific. The battles were so fierce they were named the Melanesian Nightmare. The Japanese fought fiercely. Their airpower hit our ships again and again. But while they did this they suffered heavy losses. During these battles, the Japanese lost over 2,500 naval aircraft. Most of these came from aircraft carriers.

These fierce battles took place at the same time General MacArthur's forces were closing in on eastern New Guinea. The Japanese had trouble fighting in so many places at the same time especially when they were losing so many ships, planes, and men. They lost most of their cruisers, more than half their flight crews, and two-thirds of their planes. They were crippled.

In March 1944, American forces landed at Emirau Island. This is northwest of Rabaul. MacArthur's army at the same time won the Manus Island. This is the main island in the Admiralty group. Rabaul was surrounded. The Japanese there were cut off and surrounded. The Americans simply moved past.

THE CENTRAL PACIFIC

** The U.S. Fifth Fleet began its move to recapture the Philippines by attacking Tarawa and Makin Atoll in the Gilbert Islands. **

At the same time Rabaul was being isolated, the U.S. Fifth Fleet began its move to retake the Philippines across the line of Japanese bases in Micronesia. The Fifth Fleet was to join MacArthur's forces in a combined effort to reconquer the Philippines.

The Fifth Fleet was rebuilt and Admiral Spruance was in command. They had two goals:

1. fight and destroy the Japanese naval forces wherever met.
2. support amphibious forces trying to take Japanese island bases.

The Japanese base at Tarawa in the Gilbert Islands was very heavily fortified. The Japanese had also strengthened Makin Atoll. Tarawa and Makin Atoll were the first targets.

It took three days to win Makin. Costs in men and ships were high. But taking Tarawa was much harder. One American out of six became a casualty.

The invasion started with a week of air bombing. Two days before the invasion, American battleships and cruisers moved in and shelled the beach. They fired 3,000 tons of shells in two and one half hours. Shore defenses should have been destroyed, but they were not. The Japanese garrison of 4,700 veterans were well fortified by hundreds of connected pillboxes made of concrete and coral work, reinforced with steel beams and coconut logs. Their artillery included 8-inch guns stripped from Britain's Singapore forces. Tokyo had boasted that Tarawa could not be taken by assault.

The Japanese defenses survived and were ready when the Marines came in. The landing crafts carrying the Marines ran aground on the reef and the Marines had to wade ashore for almost 1/3 of a mile. They were under heavy fire all the way. The Marines greatly outnumbered the Japanese, but the Japanese were well trained, entrenched and determined. It took the Marines three days to win the island.

The lessons learned at Tarawa were costly, but the lessons were learned. After Tarawa, softening-up bombing for amphibious operations lasted for days. Covering gunfire and aircover were more carefully controlled. The conditions for landing were more carefully studied. And armored amphibious tractors which could climb over reefs were used.

THE MARSHALL ISLANDS OPERATIONS

** The next step in the advance toward the Philippines was the Marshall Islands. **

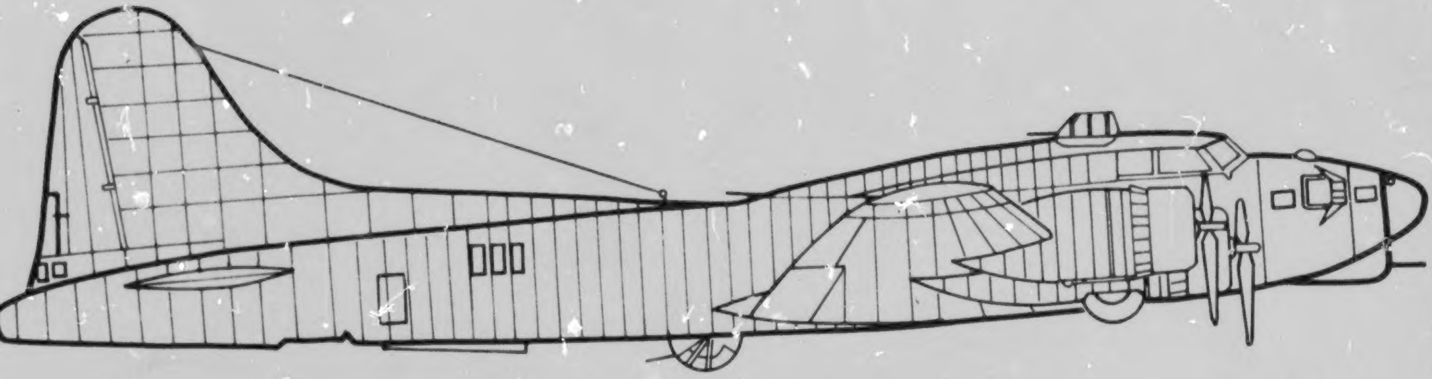
The next step in the advance was the Marshall Islands. The Japanese had five strong bases in the eastern islands of the chain. Admiral Nimitz decided to bomb the four outer island bases and then pass them all, with a main amphibious assault on Kwajalein. Kwajalein was at the center of the Marshalls. Nimitz thought that the planes from the newly-captured field at Tarawa could keep the remaining airpower on the other Japanese bases pinned down until Kwajalein was taken. Then Kwajalein would act as a stronghold for other American operations.

In Jan. 1944 the attack on the Marshall Islands began. Almost all of the Japanese planes on the Japanese bases were destroyed.

On 1 Feb. the Marines landed on Roi and Namur Islands on the northern perimeter of Kwajalein Atoll and the Army landed on Kwajalein Island on the south. The American forces captured Kwajalein in four days.

Admiral Nimitz at once moved to attack Eniwetok, the largest Japanese base in the western Marshalls. It was taken in three days. The Allies were now closer to Truk. The Japanese had held Truk since World War I. It was a mysterious place. No western man had visited it in a generation. The Japanese claimed it was so strong it could not be taken. Eniwetok is only 669 miles from Truk. On 17 and 18 Feb. Spruance's task force swarmed around Truk. The Americans attacked. First they used fighters. Then they used bombers (figure 1-19) and torpedo planes. They flew 30 strikes in all. Spruance put a ring of submarines and battleships around the Atoll to catch any ships trying to escape.

When the assault on Truk began, the Japanese had 365 planes. Less than 100 could fly at the end of the battle. Thirty-nine Japanese ships were sunk.



Length: 74.9 feet
Wingspan: 103.9 feet

Scale: 1/8" = 1 foot

Figure 1-19. Boeing B-17G Flying Fortress

Most important, the Japanese superfortress of Truk was destroyed and so was Japanese pride and morale. In the next few weeks almost all the Marshalls were secured.

LEAPFROG ON NEW GUINEA

MacArthur's forces carried by units of Task Force 58 continued to leapfrog along the northern New Guinea coast as the second prong of the general movement back to the Philippines. He would attack and win one important position and then move his forces four or five hundred miles up the coast to the next important position. His first major landing was at Hollandia. This landing's major goal was to win enemy airfields. Five hundred enemy planes were destroyed at Hollandia. The Japanese troops were driven into the jungle where they died.

The Japanese got ready for an all-out defense against MacArthur's advance. They thought that his was the one and only attack in an advance on the Philippines. As MacArthur got closer to Biak, an island farther up the coast of New Guinea, which had three major Japanese airfields, the Japanese prepared by sending almost all of their air strength to New Guinea. They also tried three times to send reinforcements by sea. The third try was to be supported by the best ships in their Navy.

On 11 June just as the Japanese got ready to sail to Biak, the U.S. Fifth Fleet, 1,000 miles to the northeast, attacked in the Marianas. The Japanese had been tricked. The Philippines were being attacked from another direction and as a result of this surprise, the Japanese cancelled the Biak defense and sent reinforcements northeast of the Philippines. Unopposed, MacArthur took New Guinea by July.

THE MARIANAS OPERATION: SAIPAN

** The amphibious invasion of Saipan in the Marianas occurred in June 1944 at the same time as the Normandy Invasion. It was almost as complicated. Together these invasions were two of the greatest military efforts in history. **

While the invasion of Normandy went on in Europe, the United States was getting ready to launch another huge amphibious assault on Saipan, in the Central Pacific (figure 1-20). In June 1944 U.S. forces composed of the 2nd and 4th Marine Divisions supported by the 27th Army Division launched the assault. 535 Navy ships, including fast carriers, transported and protected the 127,000 troops against the entire Japanese Fleet. The U.S. forces had now moved 3,000 miles across the Pacific since Pearl Harbor.

Army planes from the newly won bases in the Marshalls and Navy carrier planes from Task Force 58 hit Japanese bases in the Marianas and the Carolines. As the invasion forces prepared to take Saipan, the U.S. battleships began to bombard the island. They shelled the island for almost 3 days (13-15 June). On 15 June the two Marine Divisions moved through holes opened in the coral reef by underwater demolition teams.

Saipan was a rocky island filled with caves. The Japanese had filled these caves with 32,000 troops. They also had fortified with tanks and artillery. Against these forces the United States brought 20,000 Marines the very first day. By 17 June the Marines had landed reinforcements. After very heavy losses, the Marines captured the island's main airfield.

The following month, the Stars and Stripes returned to Guam. In a ten-day sweep beginning 21 July, Guam was retaken by the 3rd Marine and 77th Army Divisions, and the 1st Marine Brigade. The landing force crushed the last organized resistance on the island in the face of heavy rains, transportation problems, water shortages, heat, and occasionally heavy resistance. More than 1,400 Americans died in the effort. The Japanese lost 10,000 men and several hundred more who committed suicide rather than surrender. Guam was secured by 10 Aug.

Tinian, sister island to Saipan in the Marianas, was invaded 24 July by the 2nd and 4th Marine Divisions, and secured by 1 Aug after heavy resistance. Tinian's relatively flat terrain offered exceptional air base sites. In Tinian's heaviest fighting, two 2nd Marine Division regiments survived a series of desperate banzai attacks.

About the same time the Japanese Combined Fleet arrived under the command of Admiral Ozawa. Admiral Mitscher sailed out to put his forces between Ozawa and the Allied troops who were already on Saipan.

1 4

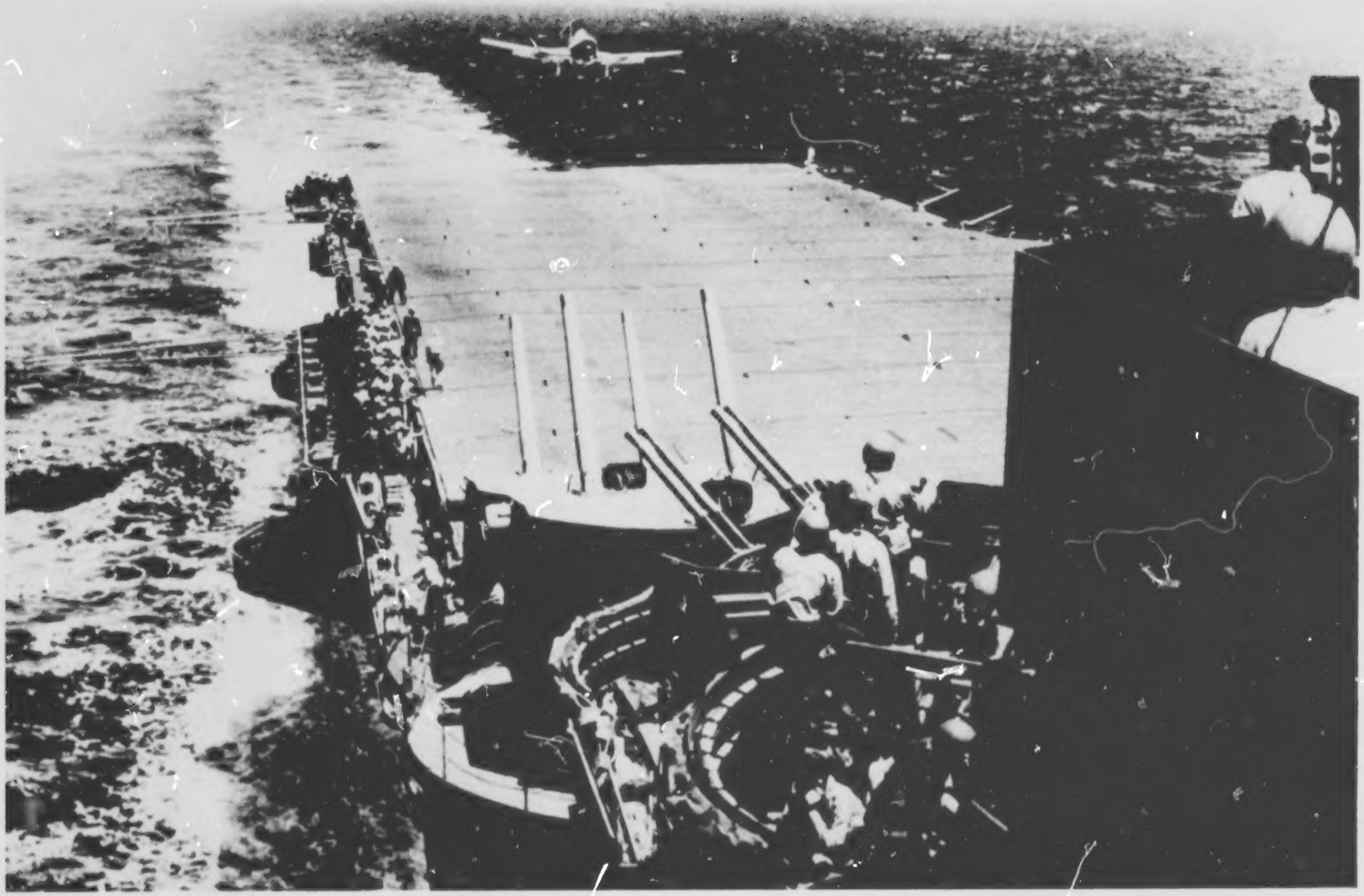


Figure 1-20. Landing of F6F on Deck of USS Lexington, Battle of Saipan, Marianas

THE BATTLE OF THE PHILIPPINE SEA

** During the Battle of the Philippine Sea, U.S. forces broke the back of the Japanese Naval Air Force. After the battle, the Japanese realized they would eventually have to surrender. **

Task Force 58 under the command of Admiral Mitscher met Ozawa's Fleet on 18 June. Mitscher's Fleet was large and he was determined to fulfill his primary orders; "capture, occupy and defend Saipan, Tinian, and Guam." Ozawa's Fleet was smaller, his carrier aircraft were outnumbered, but he too was determined to win this battle and reestablish Japanese superiority in the Pacific. Ozawa knew his Fleet was smaller, but he thought the odds would be evened by air support coming from the Empire, through the Bonins to the north. He also depended on air support from the Marianas' bases. Ozawa did not know that the aircraft he waited for had been destroyed, nor that many of his fighter pilots had returned from the Biak operation with malaria. Finally, he did not realize that his Fleet was being followed by American submarines.

And so, expecting support, Ozawa moved against Task Force 58. Spruance and Mitscher ordered 450 planes into the air. After eight hours of air battle, 330 Japanese planes had been shot down by superior American planes and battleships. History called this battle the Marianas Turkey Shoot.

In the water the American submarines closed in. The new Taiho, Ozawa's flagship and largest carrier in the world, was torpedoed just as she was getting ready to refuel her planes. She blew up. Shokaku, veteran of Pearl Harbor, was also torpedoed. She tipped over. Ozawa managed to escape by transferring to the carrier Zuikaku.

Ozawa withdrew to refuel. Even though his losses were great he planned to return and fight because he believed faulty information that said Task Force 58 had been badly crippled. Mitscher launched his planes with instructions to hunt down and destroy Ozawa's remaining ships. Mitscher knew that this was dangerous because his planes had to go farther than normal and might not be able to get back. When an American scout plane finally found Ozawa's ships, late the next day, his Fleet was 60 miles farther away than Mitscher had thought! Mitscher told his planes to attack anyhow. They did and in the action destroyed what remained of the Japanese naval air power. Meanwhile, Mitscher steamed toward the Japanese Fleet in order to cut down the distance of his pilots' return flights.

When the American planes finally returned it was night. They were almost out of fuel. The sea was dark. Then Admiral Mitscher took a dangerous chance. He ordered all the lights on the carriers turned on. He knew that prowling Japanese submarines were around. But he wanted to save his fliers. Some eighty planes either ditched or crash-landed, but as Mitscher moved west his destroyers cruised the area, picking up over sixty fliers floating in the water. Of the 216 American aviators who had fought that day, 49 were lost. Mitscher took a calculated risk to save those American aviators he commanded.

Without Japanese air power and without the strength of the Japanese mobile force, the Marianas were more easily taken. By 10 Aug., Saipan, Tinian and Guam were secure.

The Battle of the Philippine Sea marked the beginning of the end for Japan for the following reasons:

1. she no longer had a direct route from her home islands to the Carolines.

2. the U.S. now had important bases in the continuing push back toward the Philippines.

3. the U.S. now had advance submarine bases for attacks on Japanese sea and communication lanes to the Indies.

4. the U.S. now had much closer air bases from which the new long range B-29 bomber could attack the main islands of Japan.

Hirohito, Emperor of Japan, and his advisors must have known that the capture of the Marianas and the naval disaster of the Philippine Sea would spell the eventual defeat of Japan. The first outward evidence of collapse in the homeland was the resignation of the Tojo cabinet on 19 July 1944. But the Japanese military commitment was still so strong that they refused to surrender for another entire year.

IN THE PACIFIC: THE LAST BATTLES

RETURN TO THE PHILIPPINES

The Marianas were the final step in the movement back towards the Philippines. After the Marianas victories, Admiral Halsey, in command of the U.S. Third Fleet (formerly the Fifth Fleet), joined with Vice Admiral Mitscher, in command of Task Force 38 (Fast Carrier Task Force), in attacking the central Philippines (figure 1-21). The attacks were an amazing success and convinced the commanders that the central Philippines were now poorly defended. They urged that the smaller, outlying targets of Palaus and Yap, originally scheduled as early targets, be bypassed and that MacArthur be given these invasion forces so that he could launch an all-out invasion of Leyte Island, a large island in the central Philippines. It was agreed. The Joint Chiefs directed Nimitz and MacArthur to combine their forces for an invasion of Leyte but first they were to secure Morotai and Peleliu Islands in the Palaus just southeast of the central Philippines.

Morotai was easy to take, but Peleliu was very hard, mainly because the Japanese developed a new defense strategy here. Instead of trying to hold the beach they withdrew and dug in farther back in the island. This was called "defense in depth."

It was only after fierce fighting and thousands of casualties that Peleliu was taken. In the meantime, Admiral Halsey was using his carriers to keep the Japanese pinned down on their other bases in the Philippines. He wanted to make sure the Japanese on Peleliu could not get relief. During Halsey's operations he destroyed more than 200 aircraft. By this time, he was sure that the central Philippines could be defeated.

Also to prepare for the attack on Leyte, the Third Fleet attacked the islands of Formosa and Okinawa. From 11-15 Oct., the Third Fleet destroyed over 350 Japanese planes.

THE BATTLES FOR LEYTE GULF

** The Japanese realized that Leyte Gulf was the last chance for the Japanese Imperial Navy to stop the American advance in the Philippines. As a result, they mustered all the remaining forces of their Navy but were defeated. **

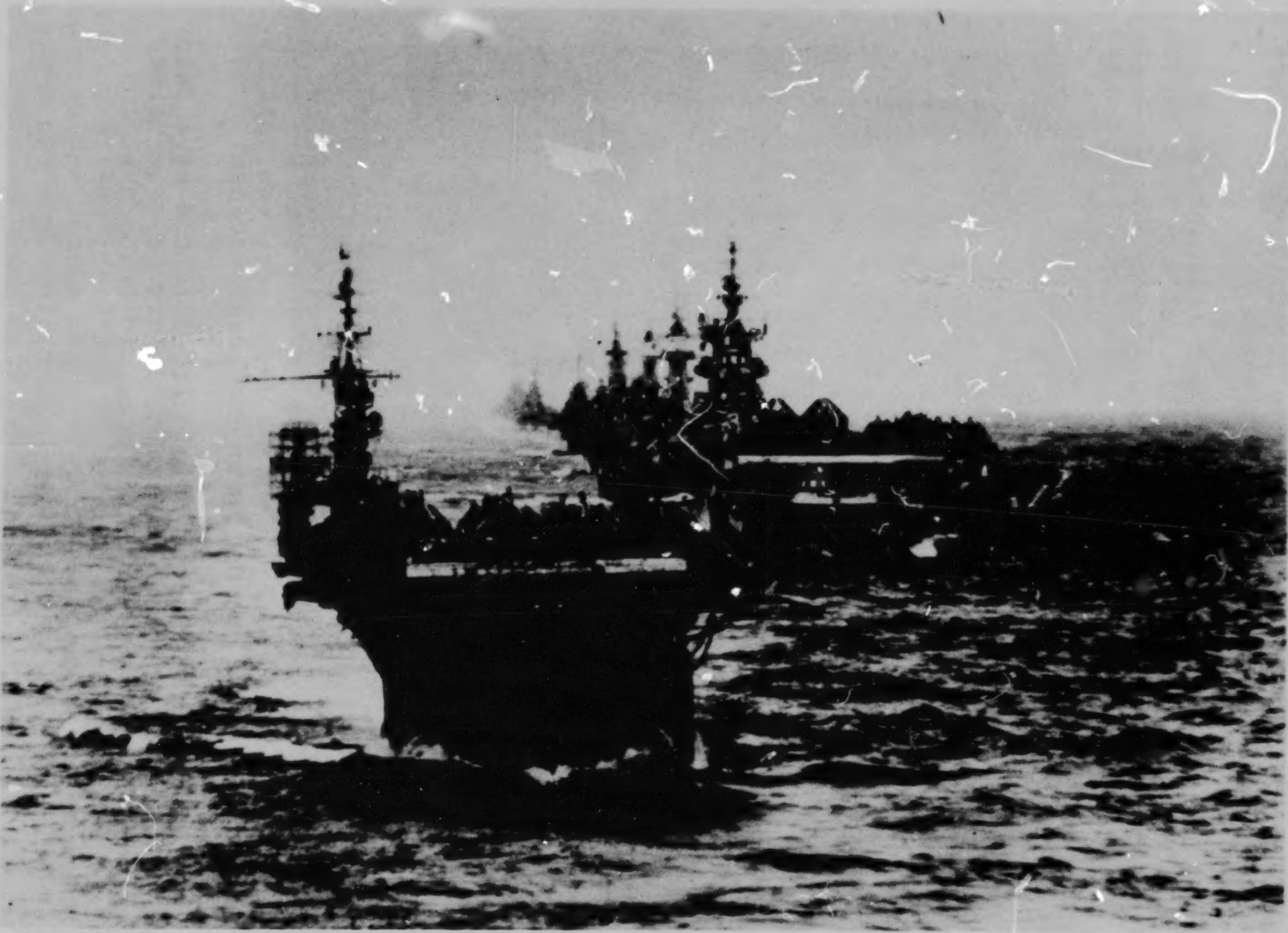


Figure 1-21. Task Force 38.3 Enters Ulithi Anchorage in Line After Strikes in Philippine Islands, 12 December 1944

D-Day for Leyte was 20 Oct. (figure 1-22). General MacArthur and Philippine President Sergio Osmena landed ashore just a few hours after the first troops landed. The Americans established their beachhead.

The Japanese knew that if the Philippines were lost, the Japanese Fleet would be totally cut off from the Indies and therefore from its crucial supply of fuel if it stayed in the North. The Fleet would also be cut off from Japan and therefore from its supply of arms and ammunition if it stayed in the South. The Fleet would be cut into small pieces and easily destroyed if the Philippines fell. Admiral Toyoda knew that this was the last chance. He knew that the Japanese Fleet had to destroy MacArthur's amphibious armada in Leyte Gulf. In four days there were four major Naval battles; the Battle of the Sibuyan Sea, the Battle of Surigao Strait, the Battle off Cape Engano, and the Battle off Samar. These four battles involved the entire Japanese Imperial Navy, composed of three major forces; the Northern Carrier Force under the command of Admiral Ozawa, the Southern Force (battleships and heavy cruisers) under the command of Admiral Nishimura, and the Central Force (battleships and cruisers) under the command of Admiral Kurita.

As Kurita's Central Force moved toward Leyte Gulf it was severely disabled. This force consisted of 5 battleships, including the 2 super-battleships, 12 cruisers and 14 destroyers. First, it was struck by submarines off Palawan Island in the South China Sea. Nevertheless, it moved on. In the Sibuyan Sea, south of Mindot, U.S. carrier planes sank the giant battleship Musashi, another cruiser and a destroyer. Still, the Central Force moved on toward Leyte Gulf.

The Southern Force entered Surigao Strait just south of Leyte and was intercepted by Kinkaid's Seventh Fleet, which was composed mainly of old battleships and other ships of the amphibious first support group. The Southern Force of 2 battleships, 4 cruisers, and 10 destroyers was totally destroyed. Only one Japanese destroyer escaped.

The Northern Force, originally intended as a decoy by the Japanese, was sighted coming toward Leyte. Halsey steamed toward the Northern Force, thinking that the Central Force was already so crippled it could not possibly continue its move toward Leyte Gulf. In other words, the Japanese plan worked! Halsey was taken in by the Japanese decoy. He

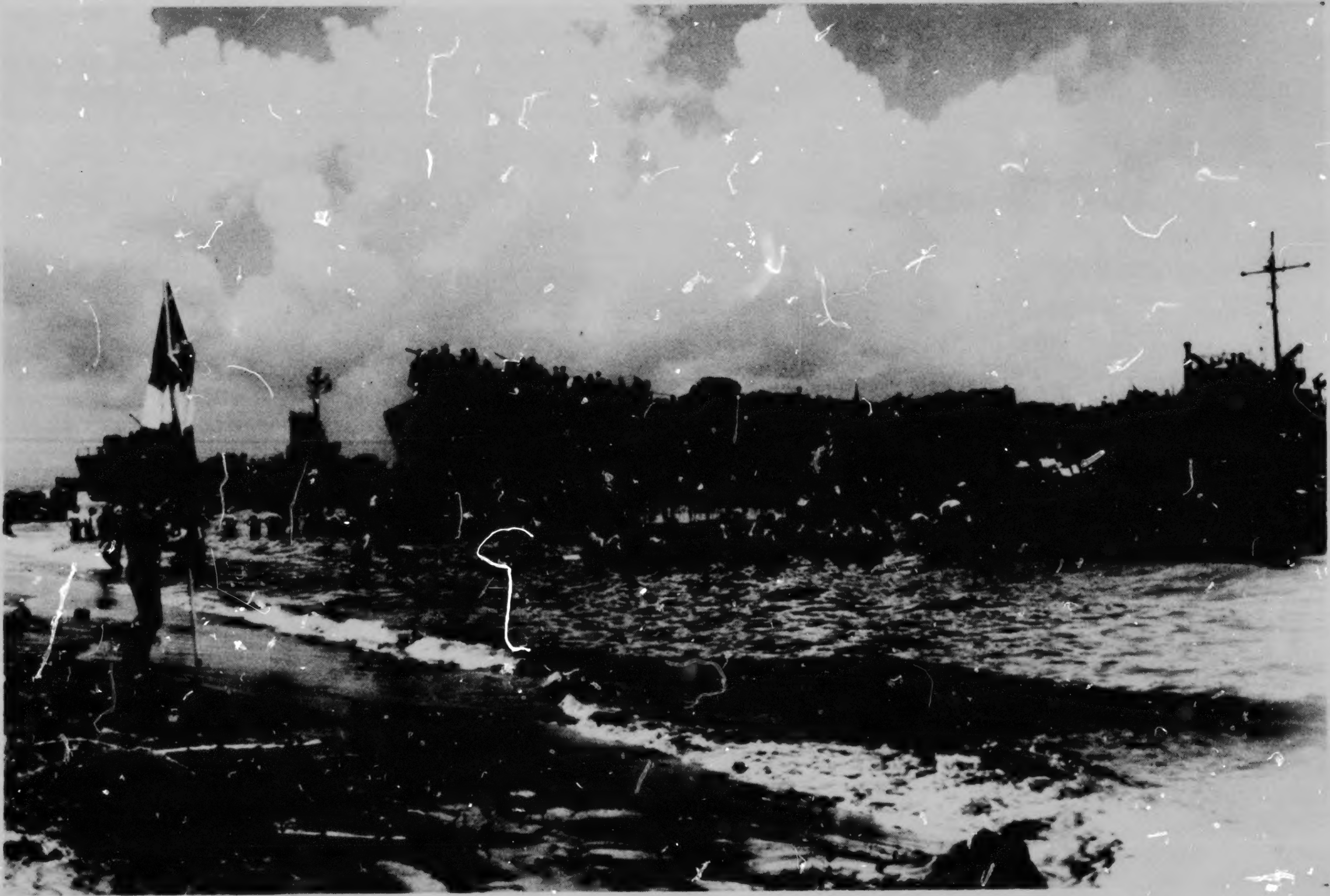


Figure 1-22. USS LST-204, LSM-23, and Landing Craft, Leyte, 20 October 1944

left the escort carriers and support forces off Samar without protection because he thought they were now out of danger. Meanwhile, the baby flattops and every support vessel, outgunned by Kurita's Central Force, used every weapon at their disposal as they drove into Kurita to keep him back. And they succeeded. They suffered severe damage but sunk two Japanese cruisers and a destroyer. The next day the American forces inflicted even more damage on Kurita and as a result Kurita withdrew in defeat.

In the meantime, Halsey met Ozawa's Northern Force off Cape Enganao, at the northern tip of Luzon Island. Halsey sank all four Japanese carriers. But Ozawa had achieved his goal. He had lured Halsey's force away from Leyte so Kurita's force could get to Leyte and destroy the unprotected amphibious task force there.

It was only because of poor communication that Kurita had turned back from his mission to reach Leyte Gulf. Kurita never received Ozawa's message that Halsey was attacking him. This is one of the strange twists of naval history because if Kurita had received the message, he would have continued and probably would have succeeded in destroying the U.S. amphibious force. But this is mere guessing. No one will ever know.

The historical result of the Battles for Leyte Gulf was that the Japanese surface navy was ruined. Its carriers were sunk and its pilots were lost and the United States went on to recapture all of the Philippines.

MULTIPLE CHOICE QUESTIONS:

1. The Solomon Islands were:

   a. Japan's bases closest to the coast of Australia.
   b. located in the Central Pacific just north of Guam.
   c. located in the North Pacific in the Aleutian Island chain.

2. Guadalcanal became the:

   a. strongest Japanese base in the Pacific.
   b. primary objective in the Battle of the Philippine Sea.
   c. primary objective in the struggle for the Solomons.

3. The Battles for Guadalcanal lasted:

   a. 6 weeks.
   b. 2 months.
   c. over 6 months.

4. Attu and Kiska were:

   a. Japanese bases in the Aleutian Islands.
   b. Japanese carrier commanders.
   c. two islands first captured by the Japanese in 1934 just off the coast of New Guinea.

5. The "Tokyo Express" was the nickname given to:

   a. Japanese bombing raids over Borneo.
   b. Japanese troop reinforcements of Guadalcanal.
   c. American fighter raids over the outer islands of Japan.

6. In 1943, Allied leaders met:

   a. with the Russian command to discuss strategies against the U-boat in the Atlantic.
   b. to discuss the possible use of Russian warships in the Pacific.
   c. to discuss future strategies against the Japanese in the Pacific.

7. The most important U.S. naval weapon in defeating the Japanese was:

   a. the submarine.
   b. the hedgehog.
   c. the battleship.

8. In landing on Tarawa, the U.S. Marines:

   a. had to wade ashore for almost one-third of a mile.
   b. met less resistance than on Makin because softening up bombing was much better.
   c. used the new amphibious tractor to climb over the offshore reefs.

9. MacArthur's strategy in New Guinea was:

   a. to move steadily up the coast from N. to S.
   b. to depend on amphibious assaults by the U.S. Marines supported by naval battleships.
   c. to leapfrog along the northern New Guinea coast.

10. During the Battles for the Philippine Sea:

   a. Admiral Ozawa did not realize that his Fleet was smaller than Mitscher's.
   b. Admiral Ozawa realized his Fleet was smaller but expected additional air support to even the odds.
   c. the Fleets of Admirals Ozawa and Mitscher were equal in size and strength.

TRUE OR FALSE QUESTIONS:

T F

1. "The Slot" refers to a sea passage down the middle of the Solomons from Rabaul. ____ ____

2. Henderson Field is an airfield located on New Guinea. ____ ____

3. During the Battle of the Santa Cruz Islands the major U.S. losses were two battleships, the Hornet and the Enterprise. ____ ____

4. The major Japanese losses during the battle for Guadalcanal were 9,000 troops and almost all their best carrier fighter pilots. ____ ____

5. The Marianas invasion and the Normandy invasion represent the second largest military effort in modern history. ____ ____

6. German submarines used in the Atlantic were larger and faster than U.S. submarines used in the Pacific. ____ ____

7. The Pacific Ocean differs from the Atlantic because it has more open waters and therefore more available trade routes for merchant ships. ____ ____

8. The Japanese considered Truk one of their weaker bases in the Pacific and therefore feared it could easily be overcome. ____ ____

9. During the Marianas operation, Mitscher's primary orders were to "capture, occupy, and defend Saipan, Tinian, and Attu." ____ ____

10. The Marianas Turkey Shoot refers to the destruction of the Japanese carrier pilots by superior U.S. planes and battleships. ____ ____

VOCABULARY SKILLS:

Using the following vocabulary words, complete the sentences below. There is only one correct, appropriate word for each blank space.

perimeter: the outer boundary line of a given area as in the Japanese Defense Perimeter.

repel: to drive or force back.

express (as in Tokyo Express): high speed.

uncharted: unmapped.

strait: a narrow waterway connecting two large bodies of water.

restricted: limited.

secured: occupied and made safe against enemy threat.

demolition: destruction by explosion.

1. The caves of Saipan were filled with 32,000 Japanese troops. Their objective was to ____________ the Marines.
2. The Japanese attempt to bring large numbers of reinforcements into Guadalcanal was nicknamed the Tokyo ___________.
3. ______________ teams were used to blast holes through coral reefs.
4. The Japanese line of bases is known as the Japanese Defense ____________
5. Waters that have never been mapped are ____________.
6. Supply routes in the Pacific were ______________ by reefs and shoals.
7. The Japanese believed that their superfortress of Truk would never be _____________ by United States forces.
8. A ___________ is a narrow waterway connecting two large bodies of water.

BRAIN TEASERS:

1. On a map of the Pacific, trace the movement of the Allies from Pearl Harbor back toward the Philippines. Along this path, pinpoint Guadalcanal, Rabaul, New Guinea, Emirau, Manus, Makin Atoll, Tarawa, Kwajalein, Truk, Saipan, Tinian, and Guam.

2. Choose one of the above islands and research its present status: government, population, industrial base, etc.

3. Research the preparations necessary for the amphibious invasion of a fictitious, occupied Pacific island. You could begin by researching the physical location and structure of any of the islands listed above. Consider in your preparations the possible contribution of demolition teams, ship support, air support, etc.

IWO JIMA

** Iwo Jima became an important strategic position because it was located between the Marianas and Japan. From here the Japanese could counteract the effectiveness of American B-29 raids on Japan by giving an early warning to the home island defenders. **

The United States could launch its giant B-29 bombers to fly missions against Japan's industrial cities. But these missions proved to be unnecessarily dangerous for several major reasons. First, Japan was a 3,000 mile round trip from the Marianas. As a result of this great distance, bombers returning from Japan would often crash into the sea because they could not hold up for the entire trip. And they were often badly damaged because the 3,000 mile round trip made it impossible for protective fighters to accompany them. They were also badly damaged because the Japanese home defenses were given early notice that bombers were on the way and, as a result, had time to scramble fighters to intercept the bombers.

All of these problems were related to the Japanese possession of Iwo Jima, a volcanic island about halfway between the Marianas and Japan.

When the Japanese forces on Iwo Jima saw the bombers fly over, they would radio the information ahead to Japan and the Japanese command there would scramble to intercept the fighters.

The Americans decided to put an end to this danger by capturing Iwo Jima. They reasoned that in American hands, the air fields on Iwo Jima could be improved and turned into emergency landing strips for wounded bombers. Iwo Jima could also provide a base for fighters which could join and escort the attacking bombers on their missions to Japan.

The Japanese realized that Iwo Jima was very important to the defense of their home islands. They expected an American assault. And so they began to build up the island's defense. They built up their forces to 23,000 troops and tunnelled through 550 foot Mt. Suribachi, an extinct volcano, on the 8 square mile island. These tunnels connected hundreds of pill boxes and concrete block houses. The Japanese placed artillery in many caves. From these positions the artillery could sweep all the beaches. In short, the Japanese transformed Iwo Jima into their strongest fortress in the Pacific.

The American Marines asked for 10 days of naval bombardment on pinpoint targets before the landing. But because of a speeded-up timetable agreed upon by the Joint Chiefs of Staff, the naval bombardment lasted only 3 days. This was not enough to do the job.

D-Day was 19 Feb. Five hundred landing craft carrying eight battalions of Marines got ready to land. They were supported by heavy naval guns. They were also supported by more than 100 TF-58 planes that attacked the Japanese defenses with rockets, machine guns, and bombs. The supporting ships provided a barrage of fire in front of and on the side of the advancing Marine assault waves.

But all of the preparatory support was not enough. The assault waves quickly piled up when they hit the beaches. The amphibious tractors were unable to climb the crumbling volcanic ash. Later, landing craft ran into earlier craft that had been stalled. The Marines had to fight their way forward inch by inch as they were hit by machine gun, mortar, and heavy gun fire that had withheld earlier fire to avoid giving away their positions. Inching forward, the Marines eventually isolated Mt. Suribachi and got to the edge of the nearest airfield. The costs were terribly high. Of the 30,000 Marines who landed the first day, 2,400 became casualties.

Fighting continued until the next day when the airfield was captured. Then the attack on the Mt. Suribachi fortress began. For three days the Marines fought inch by inch, cave by cave, pillbox by pillbox. Finally, the mountain was surrounded and a patrol got to the top and raised the American flag.

While the fighting on the island went on, the naval forces were combatting repeated Kamikaze attacks. The carrier Saratoga was damaged and the escort carrier, Bismarck Sea, was sunk. Six hundred and fifty men from these two carriers alone were lost.

The conquest of Iwo Jima was originally supposed to take five days; it took over a month. The casualties were astronomical, more than 30%. In fact, for the first time, casualties among the assault forces were higher than those among the Japanese defenders. Over 19,000 American Marines and sailors were wounded and almost 7,000 were killed.

Admiral Nimitz in admiration of the Marines said they made "uncommon valor a common virtue." Of course, he was right. The sacrifices made by the Marines resulted in a safe place to land crippled American bombers.

More than 2,000 bombers landed on Iwo Jima before the war ended. Each bomber carried a crew of 11. So one could honestly say that 22,000 members of the Air Force owed their lives to the Marines who took Iwo Jima.

OPERATION ICEBERG -- OKINAWA

** Okinawa was the last and largest amphibious assault in the Pacific. **

The next step was Okinawa. Okinawa belongs to a string of islands known as the Ryukyus. The Ryukyus stretch to the tip of the main Southern Japanese island, Kyushu. Taking Okinawa was to be the last step in the Pacific war before the real invasion of Japan. Okinawa would be the base for operations in the actual invasion of Japan.

Okinawa is the largest of the Ryukyu islands. It is 60 miles long and 20 miles wide. The attack on Okinawa turned out to be the largest amphibious landing of the Pacific War. Admiral Nimitz commanded the entire operation. It began with weeks of intensive attacks by carrier planes, land-based planes, and Naval gunfire (figure 1-23). During one attack Mitscher's Task Force 58 destroyed hundreds of Japanese planes.

The main landings on Okinawa were made on 1 April 1945 on the beaches near the central part of the island. On this day a force of 1,300 ships carrying 182,000 assault troops arrived. They had been gathered from bases all over the Pacific. 100,000 Japanese defenders awaited the attack. The American assault troops, composed of Marines and Army troops, attacked. There was little resistance. The Japanese had decided on an "in depth" defense. They kept their forces out of the reach of naval gunfire. Over 60,000 troops landed and pushed to cut the island in half.

On 6 and 7 April came the first big Japanese counterattack. This attack was made by over 350 Kamikaze planes and also by the Yamato, the biggest battleship in the Japanese fleet. Accompanying the Yamato was the light

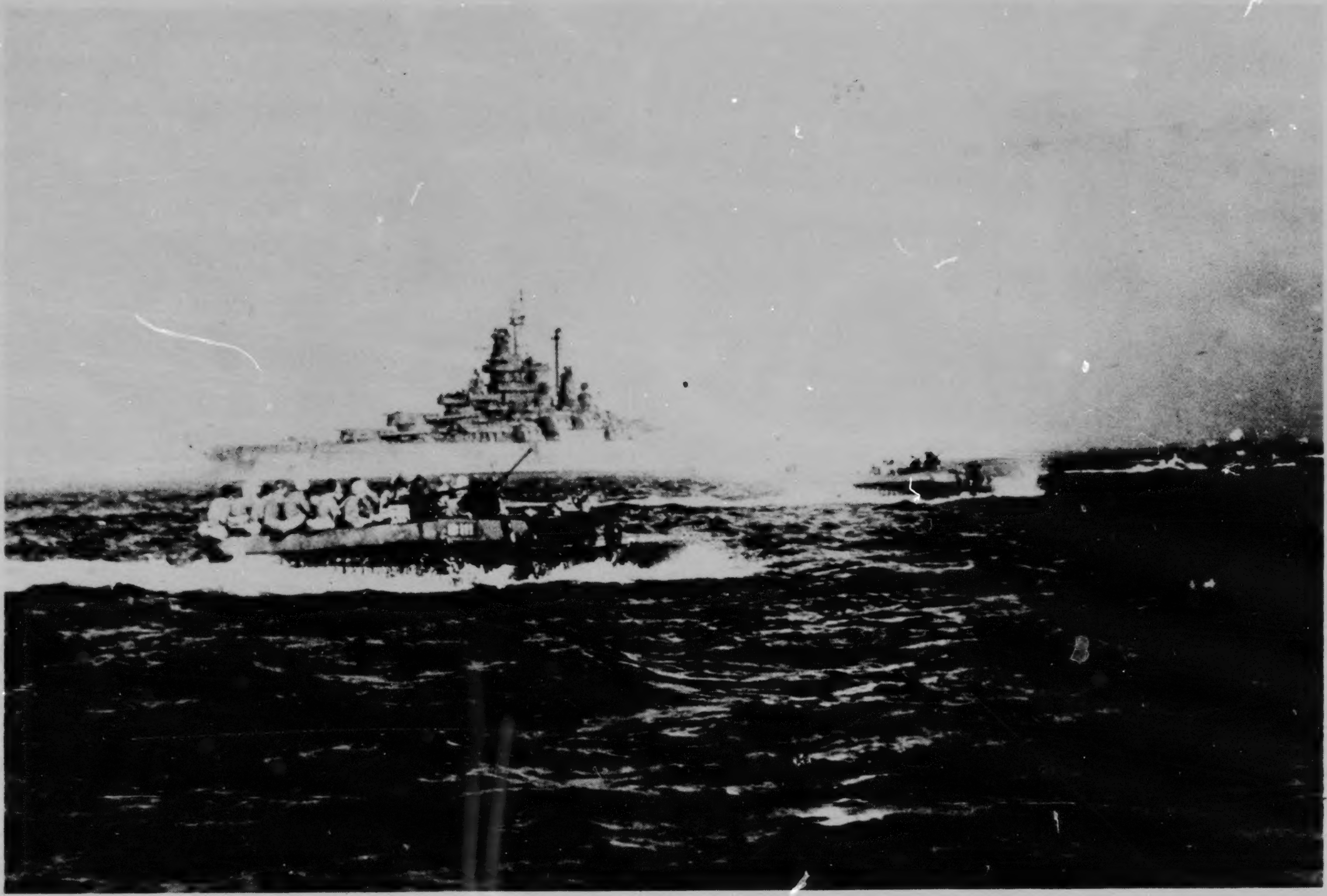


Figure 1-23. USS Tennessee Firing Salvos into Beach on Okinawa

cruiser, Yahagi, and eight destroyers. Kamikazes were planes that did not try to drop bombs. Instead, the pilots would dive straight down into a ship's deck, hoping to explode and destroy everyone. Their motto was "one plane, one ship." The Yamato force was also on a suicide mission. They had enough fuel for only one trip. They had no aircover. But the Yamato was the best armed battleship in the world. The Japanese hoped her force could severely damage the Allied Fleet after it was weakened by the Kamikazes. But the giant battleship failed. Admiral Mitscher's carrier aircraft destroyed her. Her destruction marked the end of the battleship's power in naval warfare.

By 22 June 1945, Okinawa was secure. For United States troops the Okinawa invasion was the longest and bloodiest Pacific Campaign since Gaudalcanal (figure 1-24). Total United States casualties were at least 7,000 U.S. Army and 5,000 U.S. Navy killed and 32,000 wounded. Naval losses because of Kamikazes were very heavy both in men and ships.

Okinawa was the end for Japan. A large portion of her Army had been destroyed. The Japanese lost at least 107,000 troops and had an estimated 20,000 sealed in caves. Many Japanese cities were being totally destroyed by air strikes. Emperor Hirohito told his Supreme War Council that they must find a way to end the war.

THE SURRENDER OF JAPAN

Some Japanese wanted to keep fighting to the bitter end. Others said they would only make peace if the Empire was preserved. At the beginning of 1945, Japan was still a dangerous enemy. She controlled Korea, Manchuria, and most of the richest areas of China. The Allies estimated that the enemy still had some two million troops on the home islands, and were afraid that the war could linger on until the winter of 1946.

In July 1945, the Allied leaders met at Potsdam, just outside Berlin, for a conference. During the conference, U.S. President Truman received word that the first test of the atomic bomb, at Alamogordo, New Mexico, had been an outstanding success. Hours later atomic weapons were on their way to the Marianas' bomber bases.

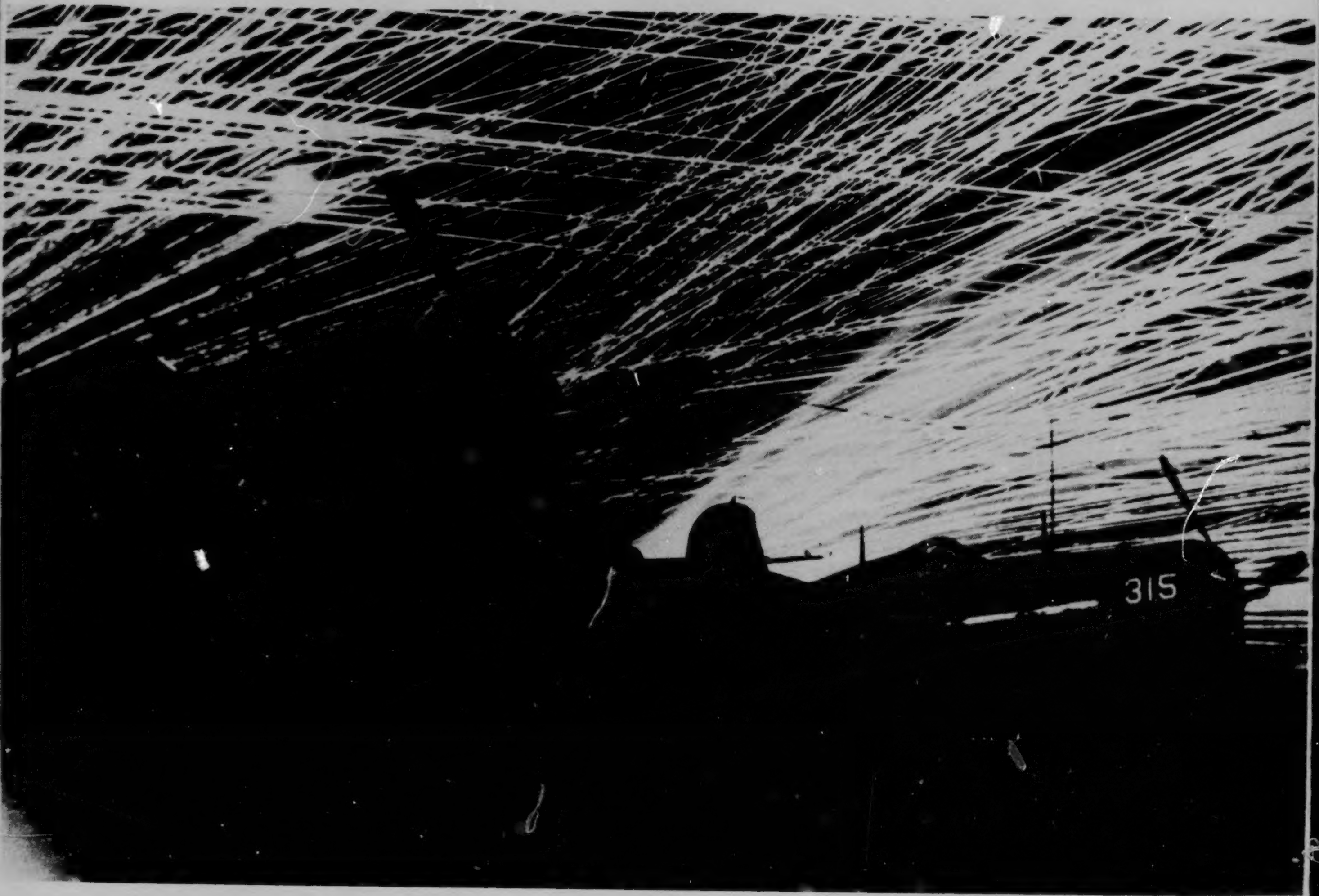


Figure 1-24. Marine Corps F4U Fighters Silhouetted Against Anti-Aircraft Tracers During a Japanese Air Raid on Yontan Airfield, Okinawa, 16 April 1945

The Potsdam Declaration was an ultimatum issued to Japan by Truman, Churchill and Chiang-Kai-Shek on 26 July 1945. It threatened Japan with prompt and utter destruction without mentioning the new bomb or the Emperor's status. It demanded:

1. unconditional surrender but only for military forces.

2. give up all possessions except for the Japanese home islands; Hokkaido, Honshu, Shikoku, and Kyushu.

The Japanese hesitated in their decision to surrender. On 28 July the Japanese Prime Minister Suzuki announced that his cabinet would "mokusatsu" the ultimatum. "Mokusatsu" could be translated to mean either "ignore" or "withold comment on." Meanwhile, the British and Americans got ready for a November invasion of the main island of Kyushu. They planned to follow this with a March assault on Honshu.

But these plans were never carried out. President Truman took "mokusatsu" to mean "ignore" and gave instructions that the first bomb should be dropped. On 6 Aug. a B-29 dropped an atomic bomb on Hiroshima, an industrial city of Japan. The city was totally destroyed.

On 9 Aug. a second atomic bomb was dropped on Nagasaki and leveled it. Hirohito told the Supreme Council to accept the Potsdam Declaration. The Council agreed but only if the imperial system remained. The United States accepted with two conditions; (1) the Emperor must submit to the Supreme Allied Commander during the occupation of Japan and (2) the Japanese people would later hold a free election to decide what place the Emperor should have in the future. On 2 Sept., aboard the U.S.S. Missouri, the surrender was signed. General MacArthur took over to direct the occupation of Japan. The war was over.

MULTIPLE CHOICE QUESTIONS:

1. Iwo Jima is located:

   a. off the coast of Hokkaida.
   b. about halfway between Japan and the Marianas.
   c. near Wake Island.

2. From Iwo Jima:

   a. the Japanese launched major air strikes against American bases in the Carolines.
   b. the Japanese warned the home-island defenders that B-29 raids were coming.
   c. America launched the B-29 that dropped the Atomic bomb on Nagasaki.

3. One of the major natural obstacles on the beach at Iwo Jima was:

   a. barrier reefs.
   b. volcanic ash.
   c. mined harbors.

4. The mountain fortress on Iwo Jima was:

   a. Mount Suribachi.
   b. Mount Fuji.
   c. Mount Olympus.

5. A kamikaze is:

   a. a Japanese plane which tried to dive straight down into a ship's deck, hoping to explode it and destroy everyone.
   b. the Japanese admiral in command of the carrier Yamato.
   c. a small Japanese amphibious ship.

6. Okinawa is part of the:

   a. Ryukyu Islands.
   b. Caroline Islands.
   c. Aleutian Islands.

7. The Potsdam Declaration:

   a. planned the bombing of Hiroshima and Nagasaki.
   b. spelled out the peace terms with Japan.
   c. declared Japan's resolution to fight to the bitter end.

8. Alamogordo is located in:

   a. New Mexico.
   b. Arizona.
   c. Texas.

TRUE OR FALSE QUESTIONS:

T F

1. American B-29's flew strikes against Japan from the Marianas. ____ ____

2. It was about 3,000 miles round trip from the Marianas to Japan. ____ ____

3. The tunnels in Mt. Suribachi connected well over 2,000 separate pill boxes. ____ ____

4. In the invasion of Iwo Jima, the Marines requested three days of naval bombardment on pinpointed targets. ____ ____

5. The conquest of Iwo Jima took five days. ____ ____

6. Operation Iceberg, refers to the invasion of Okinawa. ____ ____

7. Okinawa was second to the final amphibious assault in the Pacific. ____ ____

8. The Ryukyus touch the tip of the main southern Japanese island, Honshu. ____ ____

9. The Yamato severely damaged the allied Fleet during the invasion of Okinawa. ____ ____

10. The Japanese surrendered on 2 Sept. aboard the USS Missouri. ____ ____

VOCABULARY SKILLS:

Using the following vocabulary words, complete the sentences below. There is only one correct, appropriate word for each blank space.

intercept: to stop an enemy's progress.

pinpoint: exceptionally accurate.

1. Exceptionally accurate bombing is sometimes also called ____________ bombing.

2. A severe blow to Japanese naval leadership occurred when American planes ____________ed and shot down Admiral Yamamoto's plane.

CHAPTER II: NAVAL LEADERSHIP

THE GREATEST DISCIPLINE: SELF-DISCIPLINE

** Each society is only as safe as the self-control exercised by each of its members. **

"Few things are harder to put up with than the annoyance of a good example.".....Mark Twain

In the above quotation, Mark Twain is telling us a truth in the form of a joke. After all, who among us has not felt the pressures of a good example? The coach who requires her swimmers to be at practice by 7 a.m. and then is there to greet them--in her swimming suit--shows that she is asking no more of them than of herself. At first, this is easy to take. But after a month of practice, some of the student swimmers might secretly wish the coach would not always be so perfectly on time! "How does she get up so early?" "How can she be so cheerful?" they might joke to one another. But secretly the conscientious swimmer would probably be asking him/herself, "How can I do less for the team than she does?" The coach sets a tough example but one worth following.

"I know no safer depository of the ultimate powers of the society but the people themselves, and if we think them not enlightened enough to exercise their control with a wholesome discretion, the remedy is not to take it from them, but to inform their discretion.".....Thomas Jefferson. (In other words, the success of a society depends on the people themselves. If we don't think them capable of running their affairs, we should teach them the proper way, not take responsibility away from them.)

Thomas Jefferson expands on Twain's idea. Basically, he is saying that each society is only as safe as the self-control exercised by each of its members. Further, Jefferson is saying that it is much healthier to develop people so that they can discipline themselves than to make endless rules and regulations which undisciplined people will have trouble following anyhow. Individual self-discipline is the key to Jefferson's thought.

If all members of a society could be educated to high personal standards, and conducted themselves by those standards, the society would be strong. The society would be filled with people who are both leaders and followers at the same time. This last sentence sounds puzzling. How can someone be a leader and a follower at the same time? Actually, the answer is simple. Each member of the group would be both leader and follower because each would understand the need to dedicate him/herself to accomplishing the overall good.

We can use the team concept again to illustrate this point. Usually, a basketball team has one or two best shooters. In a sense, these players act as leaders scoring large numbers of points. At important moments in a game, the team tries to maneuver the ball to these players. But a team can only be successful if these players also have the intelligence and self-control to know when they are not shooting well. On good teams, during this situation a sudden change will occur. The off-shooters will quickly change roles. They will reduce the number of their shots and begin passing the ball to other team members. They will try to be more helpful to the team by setting up plays rather than by shooting. In other words, they will become supporting members of the team. They will exercise self-control because they understand it is necessary for the team's overall success.

A strong democratic society (organization) would be as unselfish as the above basketball team. Each member would be internally disciplined and would recognize the society's most important needs. And, of course, in recognizing these needs, each would be willing to follow or to lead as the situation demanded. There would be no need for orders, or written laws.

If Jefferson's idea could be completely realized, there would be no need for orders, carefully worked out military ranks, or even assigned tasks. In fact, there would probably not even be a need for laws. The complete realization of his idea would make a perfect democratic society.

THE NAVY'S NEED FOR LEADERS

** A complicated society like the Navy realizes the need to develop outstanding leaders who are capable, first, of developing their own high standards, second, of leading others to follow those standards, and third, of helping their subordinates to develop their own standards. **

But, of course, although people have dreamed of making such a perfect society, none has ever existed. A perfect society is called a utopia. The Navy long ago realized it was not a utopia. It is, however, a huge society made up of many different kinds of people with enormously complicated jobs to do. The larger a society, the greater the variety of people in it, the more related jobs there are, the harder it is to get everyone working together. How many separate, but related, jobs are there on even a small ship? How many are there on a nuclear submarine? How many separate people does a Navy fighter pilot depend upon for his very life once he climbs into the cockpit and takes off? Because it is not a utopia and because it is a complicated society with a complex and important job, the Navy realizes a very basic need: to develop outstanding leaders who are capable, first, of developing their own high standards, second, of leading others to follow those standards, and, third, of helping their subordinates to develop their own standards so that each member of the Navy can go on developing.

One of a Naval leader's greatest accomplishments is to inspire his/her subordinates to self-discipline and the highest of personal standards. Self-discipline sounds like a simple enough trait. But when you think about it, you realize how demanding it is. One example from our chapter on World War II should be enough to illustrate this point. Do you recall Admiral Mitscher's decision to turn on all the lights of his carriers so that his fighter-pilots could find a safe landing? Try to imagine the difficulties that Admiral Mitscher must have gone through to reach his final decision. He had to weigh the possibilities of all the ships and men under his command being attacked by the Japanese. He had to weigh the other possibilities of hundreds of fliers drowning by being lost at sea if the carrier lights were not turned on. Where were the greatest demands of duty? He finally came to his decision. He must risk the chance of attack to save his fliers. And when he gave the order to turn on the lights, many of the very men whose lives were put in danger cheered his decision. They recognized the difficulty of his decision and how much he cared about the fliers. They were willing to follow him in his decision to save their comrades. What did their cheers mean? They meant that under the most difficult conditions Admiral Mitscher had achieved the great leader's goals: (1) obedience, (2) respect, (3) confidence, and (4) loyal cooperation from his men. Only a leader with great self-discipline could have faced and made such an agonizing decision.

Admiral Mitscher's decision is, of course, a dramatic example. But in many ways, it is representative. Naval officers and petty officers are continually aware of the important obligations and decisions which come as part of their rank.

For example, aboard ship, often it is a petty officer's intelligent decision and performance that count most. Consider that often the petty officer is in immediate charge of the engine room. In case of a malfunction, the petty officer must quickly determine what must be done for emergency repairs. If a fire breaks out, again it is often the petty officer and crew who fight it. The lead medical corpsman is often the petty officer. In case of emergency first aid, the duty to make clearheaded decisions once again falls upon the petty officer. We are not all Admiral Mitschers. But the need for self-discipline and courageous action in the Navy in real and important situations will cross many of our paths.

Consider what it means to be an officer or petty officer in the United States military. The complicated task of the United States military is no less than protecting the American people. In order to perform this duty, the American people designed a government giving the military a great deal of authority. And this authority is transferred through a chain of command which starts with the U.S. Constitution, i.e., the President, and goes through to the Department of Defense, to the commissioned Naval officer and on down through the chain of command to all naval petty officers. The following passage, taken from the Certificate of Appointment Commission for petty officer (figure 2-1), illustrates the obligations of authority:

TO THE APPOINTEE

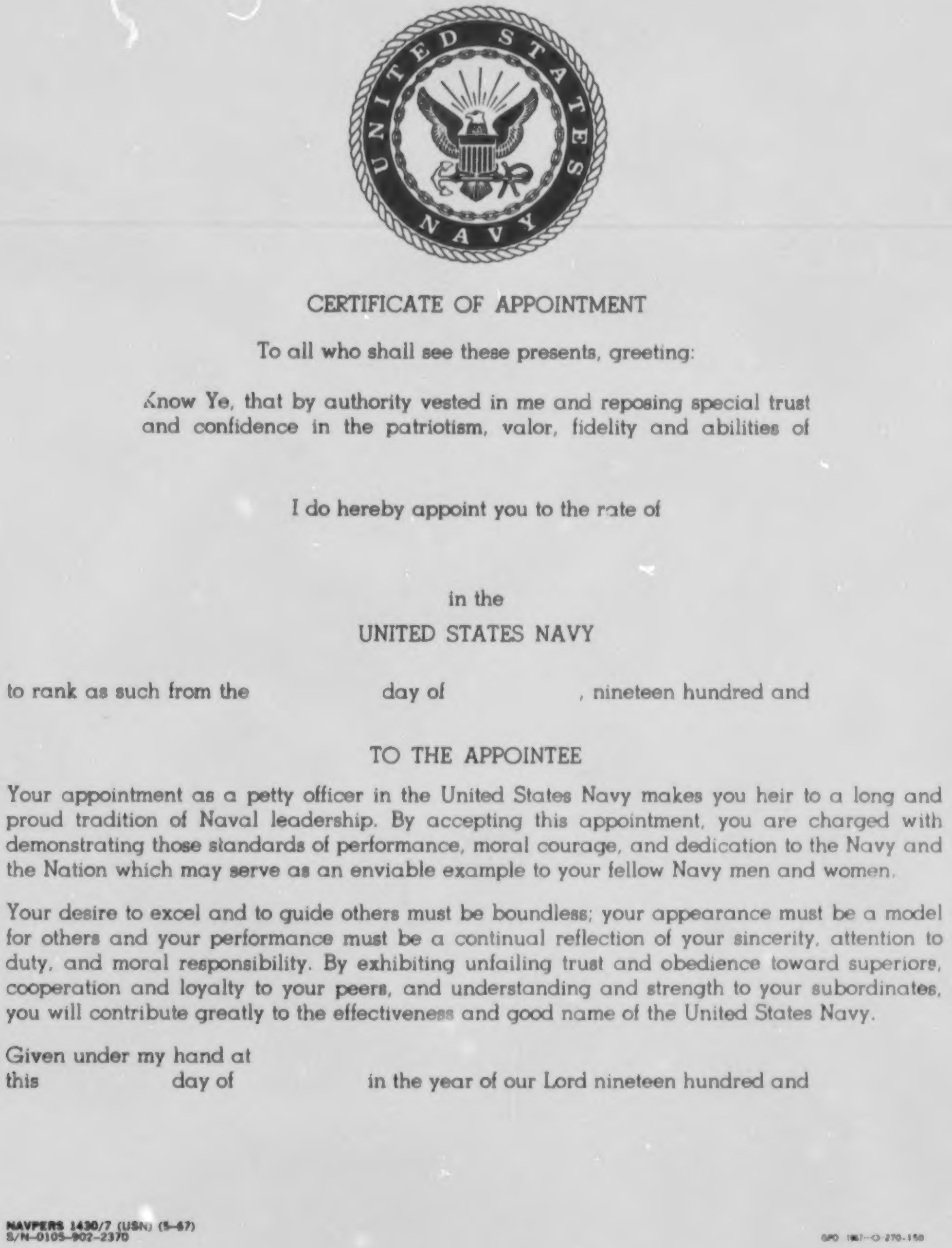
> Your appointment as a petty officer in the United States Navy makes you heir to a long and proud tradition of Naval leadership. By accepting this appointment, you are charged with demonstrating those standards of performance, moral courage, and dedication to the Navy and the Nation which may serve as an enviable example to your fellow Navy men and women.
>
> Your desire to excel and to guide others must be boundless; your appearance must be a model for others and your performance must be a continual reflection of your sincerity, attention to duty, and moral responsibility. By exhibiting unfailing trust and obedience toward superiors, cooperation and loyalty to your peers and understanding and strength to your subordinates, you will contribute greatly to the effectiveness and good name of the United States Navy.

Up the scale in rank, for the chief petty officer, it reads in part:

TO THE APPOINTEE

> Your appointment carries with it the obligation that you exercise additional authority and willingly accept greater responsibility. Your every action must be governed by a strong sense of personal moral responsibility and leadership....

With increased authority (higher rank) comes even more obligation and responsibility. Only people who have already established high standards through self-discipline are ready to carry out these demanding obligations. And an officer and petty officer must carry them out. He/she should also realize that these obligations are legal as well as moral. In a real, practical way, a petty officer's responsibility to his subordinates differs from that of an employer in civilian life. After all, in civilian life, an employee goes to work for an average of eight to ten hours. Employees perform their services for the company and return home. Furthermore, at work, not only the employer but often the union has much to say about work obligations and working conditions.



CERTIFICATE OF APPOINTMENT

To all who shall see these presents, greeting:

Know Ye, that by authority vested in me and reposing special trust and confidence in the patriotism, valor, fidelity and abilities of

I do hereby appoint you to the rate of

in the

UNITED STATES NAVY

to rank as such from the day of , nineteen hundred and

TO THE APPOINTEE

Your appointment as a petty officer in the United States Navy makes you heir to a long and proud tradition of Naval leadership. By accepting this appointment, you are charged with demonstrating those standards of performance, moral courage, and dedication to the Navy and the Nation which may serve as an enviable example to your fellow Navy men and women.

Your desire to excel and to guide others must be boundless; your appearance must be a model for others and your performance must be a continual reflection of your sincerity, attention to duty, and moral responsibility. By exhibiting unfailing trust and obedience toward superiors, cooperation and loyalty to your peers, and understanding and strength to your subordinates, you will contribute greatly to the effectiveness and good name of the United States Navy.

Given under my hand at
this day of in the year of our Lord nineteen hundred and

NAVPERS 1430/7 (USN) (5-67)
S/N-0105-902-2370

GPO 1967-O-270-150

Figure 2-1. Certificate of Appointment, U.S. Navy Petty Officer

A subordinate in the Navy goes to work for 24 hours a day. That is, officially the sailor is on call all the time. Further, the sailor's duties are totally defined and controlled by the Navy. For these reasons alone, the officer's and petty officer's control and responsibilities are greater than in a civilian situation. By accepting a commission, an officer legally agrees to represent the United States government and it is the duty of the United States government to represent the best interests of all its people. Those subordinates under the officer's command are in his/her charge and it is his/her duty to look after their well-being.

MULTIPLE CHOICE QUESTIONS:

1. Twain believed:

   a. people are pleased by a good example.
   b. a good example is easy to set.
   c. people are often annoyed by a good example.

2. Jefferson thought that the success of a society depends on:

   a. one strong leader with unlimited power.
   b. each citizen having self-control.
   c. a few strong leaders dividing the duties of government.

3. If each member of the society were controlled by a set of high moral standards:

   a. there would be a need for stricter laws.
   b. the crime rate would not change.
   c. there would be no need for orders, written laws, or even ranks.

4. A utopia is:

   a. a perfect society.
   b. the Navy.
   c. a society in which each member tries to be the most important leader.

5. One of a Naval leader's greatest accomplishments is to:

   a. force his/her subordinates to follow orders without question.
   b. inspire his/her subordinates to self-discipline and the highest of personal standards.
   c. require high standards of subordinates no matter what the leader himself/herself does.

6. A petty officer receives his/her authority from:

   a. a chain of command which starts with the U.S. Constitution.
   b. the Admiral.
   c. the Department of Defense.

7. With increased authority (higher rank) comes:

   a. higher salary and less responsibility.
   b. more obligation and responsibility.
   c. greater personal power and fame.

8. In a practical way, the petty officer's responsibility to his/her subordinates differs from an employer's in civilian life because:

   a. a sailor is actually on call 24 hours a day.
   b. a sailor is on call 10-12 hours a day.
   c. the Navy is a more responsible organization than most civilian companies.

9. A petty officer's Certificate of Appointment includes:

   a. standards of performance, moral courage, and dedication to the Navy and the Nation.
   b. statements about rank and corresponding pay schedules.
   c. an outline of the Navy's system of promotion.

10. Admiral Mitscher's decision to turn on the lights of his carriers was the result of:

    a. his realization that there was little danger of attack because Japanese fighter planes were in Hawaii.
    b. his decision to risk the chance of attack to save his fliers.
    c. direct orders from Admiral King.

TRUE OR FALSE QUESTIONS:

T F

1. Individual self-discipline is the key to Jefferson's thought. ___ ___

2. In a perfectly democratic society a good leader would also be a good follower. ___ ___

3. Increased rank involves decreased obligations. ___ ___

4. A good leader wants the following four responses from his/her followers:

   obedience, respect, confidence, and loyal cooperation. ___ ___

5. Navy jobs are related to one another and people must depend on others to successfully perform their jobs. ___ ___

6. Self-discipline is a simple trait to acquire. ___ ___

7. A petty officer is often the head medical corpsman on a ship. ___ ___

8. Admiral Mitscher's men were upset with his decision to turn on the carrier's lights because this would endanger their lives. ___ ___

9. An officer or petty officer's obligation to subordinates is moral but not legal. ___ ___

10. The obligation of a civilian employer is approximately the same as the Navy's. ___ ___

VOCABULARY SKILLS:

Define the following vocabulary words. Complete the sentences below. There is only one correct, appropriate word for each blank space.

annoyance

agonizing

discipline

moral

obedience

obligation

utopia

1. By practicing 3 hours a day the swimmer was showing ____________________.
2. The petty officer felt it was his/her __________________ to correct the recruit.
3. Recruit training proved the Navy was no ____________________.
4. The mission required _________________________ from each sailor.
5. Admiral Mitscher's decision was personally ___________________________.
6. It is difficult to put up with the _____________________ of a good example.
7. Abraham Lincoln freed the slaves because he felt it was the _______________ thing to do.

BRAIN TEASERS FOR CLASS DISCUSSION:

1. In what practical ways have you found self-discipline important in your own life?
2. In what practical situations might a petty officer demonstrate leadership aboard ship?
3. What small examples of self-discipline can you cite from newspaper accounts of "ordinary" persons' lives?

THE BEHAVIOR OF A LEADER

** Leaders do not all behave alike, but most do some things similarly. **

Leaders do not all behave alike. In fact, their individual personalities and, most important, the way they express themselves in word and deed, probably have much to do with their ability to command other people to obedience, confidence, respect and loyal cooperation. But whether outwardly cold or warm, physically strong or frail, loud or quiet, most do some things similarly.

ASSUMES RESPONSIBILITY

** A leader is willing to take on the responsibility of preparing to make decisions and making decisions that affect others. **

The first characteristic probably underlies all the others. A leader is willing to set an example. He/she wants to say, "I am a person worthy to take on the responsibility of making decisions that affect others." What does this mean? First, it means that the leader is interested in the welfare of others, that the leader cares not only about how well he/she functions but also about how well other members of the crew are able to function. And the leader is interested in helping all others do their jobs better. This means the leader wants to think carefully about each crew member's abilities and needs and wants to assign jobs that each sailor can best fulfill. It implies that the leader wants to schedule work assignments, to set goals, and to define standards. Finally, it means that the leader wants to think carefully about how successfully the tasks have been achieved and to make careful judgments about these.

In the military, a leader is ultimately faced with the reality that a decision made for others may mean the difference between life or death. So in the military, the willingness to accept the responsibility of making decisions leads logically to the need for deep self-study, clear thinking, and constant personal development. The military leader feels an obligation to become the very best person he/she can become.

ACTS ETHICALLY AND MORALLY

** All real success depends on a high code of personal honesty and integrity. **

The leader understands that his power obligates him to the people under his command. Personal dishonesty, for example, making a decision on pretended rather than real knowledge, will endanger the success of a mission and possibly the lives of everyone involved. The leader realizes that to be effective he must learn to be honest with himself. A leader must accurately assess his own strengths and weaknesses. Moral rules must be written not on paper but in what one does; all real success will depend on a high code of personal honesty and integrity.

IS LOYAL

** A leader knows that loyalty is a two-way street. **

Just as the leader takes on a moral obligation, he/she takes on the obligation of loyalty as well. The leader must be dedicated to his/her subordinates in order to get the subordinates' loyalty in return. In times of crisis; nothing less than loyalty will do. This is the test. In times of crisis, when both sides are equal, it is loyalty that counts most.

The leader understands that once again he/she must set the example in devotion to country, organization, and followers. Devotion means that often one must set aside his/her own personal wishes for the good of the organization. Perhaps the greatest challenge to loyalty for the educated person, is the ability to see weaknesses in any project or organization and still remain loyal for good reasons. As we pointed out earlier, there are no utopias. But the educated man or woman in the Navy has thought carefully about why they are devoted. Perhaps being willing to serve and even die for a less than perfect cause is the greatest loyalty. The obligation of loyalty, like that of morality, is an internal feeling. The leader must feel and think devotion from the inside. The leader and not anyone else must be the one to measure his/her own efforts.

PERFORMS HIS/HER DUTY

** The leader must insist that each task be done well, that each task be assigned a priority, and that each task

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be assigned a proper amount of time for completion. **

You have heard the expression, "Any job worth doing is worth doing well." "Devotion to duty" takes the expression much further. It says that getting the job accomplished in the best possible way is the duty and obligation of every person from recruit to petty officer to officer. The leader knows that he/she must set their own devotion to duty as an example to subordinates. The leader knows that a flier could die because a mechanic's helper had not believed it was exceptionally important to precisely tighten a bolt. So it is important to perform each duty well. But the leader must realize also that given a certain amount of time and an overall goal, he/she must put an order of importance (priority) on each task. In short, the leader must decide which task is most important, which less, and so on. The good petty officer in charge of the maintenance functions in an engine room sometimes must assign priorities to performing maintenance. For example, some tasks if not performed immediately could cause a safety hazard or could shut down the engine entirely. Other maintenance that should be done could be delayed without causing damage or, at least, great damage. The leader must also be able to say, "Spend more time on maintaining a critical valve, and less time on replacing a corroded casing." In other words, the leader must be able to see that time is not stretchable like a rubber band. He/she must be able to answer "How can I best use this time to achieve our goals?" Being able to properly manage time is just one more important part of the leader's self-discipline.

INCREASES PROFESSIONAL KNOWLEDGE

** A leader must be continually interested in self-development. **

Every leader realizes that there is always something more to learn in order to perform duties just a little better. "The smartest man is probably the man who realizes he is not the smartest man" is not a mindtwister. It is true. The leader is continually trying to increase his/her ability by acquiring new knowledge from schools, books, from practical experience and from any persons who have something to teach. By having such an attitude about personal development the leader will encourage it in his followers. The leader is always attempting to build upon and beyond current abilities.

WORKS TO BUILD SELF-CONFIDENCE

A leader recognizes that full ability and self-confidence must be developed.

It is clear that real self-confidence only comes from knowledge and achievement. We all feel confident about a task that we know we can do well. The leader makes sure that he/she does each job as well as it can be done. But we all know that often we are called on to act in a new situation without a lot of past experience and therefore without a lot of confidence. In such a situation, we must sometimes be willing to take personal risks and assume responsibilities we do not feel quite ready for. Probably no one is ever fully prepared for any new job. If the leader does not know how to fully perform a task, he/she does not try to lie or bluff his/her way through. Rather, he/she attempts to learn how by asking someone who already knows or by studying the problem. The leader realizes that self-confidence comes only as a result of real, honest achievement. In a new situation, achieving self-confidence is often difficult but is necessary and worth the effort involved. The leader also knows that one can only inspire confidence and respect in others by first having it in oneself.

TAKES CALCULATED RISKS

** Often a leader has to act on a carefully informed guess. **

Only initiative combined with knowledge is successful. Initiative simply means making a personal, original move to solve a problem. Ideally, full knowledge of the problem is necessary before taking any action. A leader realizes he/she has the obligation to know as much as possible about the history of a problem, and the past attempts to solve the problem. The most inventive people first want to review the solutions others have tried. No responsible leader wants to foolishly repeat the errors of the past simply because he/she did not take the time to find out what they were. At the same time, leaders are never absolutely sure that what they do is going to work out the way it was planned. Accepting normal defeat is a necessary reality to acting on your best informed guess. If we could reach into the private thinking of all people in authority, we might find that the whole world is being run by people who are not quite ready yet. The best leaders are probably those people who realize they are never perfectly prepared and are therefore always trying to do just a little more to get prepared.

ACTS IN SPITE OF FEARS

** A courageous leader overcomes fear and accomplishes the task.**

Like duty and moral obligation, courage is hard to define. Simply, it is that behavior a person does when the temptation to give up and not do it is very strong. It means being able to make yourself work as hard as necessary to accomplish your goal. It also means being able to overcome your fear of failing. The test of personal courage comes in too many forms to list. But one thing is clear. The more a person is allowed to exercise courage, the more it grows. Each time a person overcomes fear and accomplishes a task, that person is developing courage. And although our most famous examples of courage come from battle stories, most of us develop this trait in more quiet, everyday situations. In fact, most of us develop courage as we live through everyday problems. Mitscher is again a good example. He had an early test during his days at the Naval Academy. After devoting himself to Academy work for three years he was told that he would not graduate because he had failed one course. He faced the prospect of telling his parents and friends of his failure. Plans had to be cancelled. Lesser men might have felt humiliated, and quit. But Mitscher accepted the disappointment and reasoned that he must keep trying until he successfully completed the class and graduated. Who can say that meeting and conquering this one academic problem was not the important first step in the development of courage that made him one of the most valiant and courageous commanders in World War II? Developing courage is a process in which we are involved each day of our lives.

Through its rigid training program the Navy tries to help its leaders develop the courage they'll need to overcome the obstacles they may face. Courage is "stick-to-it-iveness," and strength of character. It is the mark of an adult thinking clearly about his fears and acting correctly in spite of them.

ORGANIZES AND MAKES DECISIONS

** A leader tries to organize work and make decisions without bias and for everyone's good. **

A leader is willing to take charge of a situation, to organize personnel, and to make and bear the responsibility of decisions. Essentially, the potential leader is saying, "I believe I am the most capable person here for understanding the situation and I will make a decision based on all the facts available, studied carefully and honestly." The leader is also saying, "I will try to make the decision for everyone's good and I will try to make it without bias." No followers can ask more; no leader should offer less.

SETS A PERSONAL EXAMPLE

** The leader sets an example he/she expects subordinates to follow. **

The last behavior of a leader returns to Mark Twain's truthful joke. The conscientious young swimmers may be annoyed by the coach's example but they want to follow it. Once more, they want, need, and respect that annoying example!

A leader cannot expect honesty in his followers without first showing honesty. A leader cannot expect morality without being moral. He/she cannot expect self-discipline without demonstrating it.

In short, there is nothing more important in leadership than setting the example. Humans are imitating animals. As children, we dress-up like our parents. As adults, we write plays or stories that imitate life. People in an organization also imitate. Look at the people in an organization and you'll have a pretty clear picture of their officer. They will reflect the officer's honesty, loyalty, efficiency and care if this is what is shown them! The old expression "Do as I say, not as I do" is rewritten by the Naval leader as "Do as I do. I expect no more or less from any of you! You are my mirror; I am yours."

MULTIPLE CHOICE QUESTIONS:

1. A leader is most interested in:

    a. only how well he/she completes a task.
    b. how he/she and other members of the crew perform assigned tasks.
    c. getting rid of people who have personal problems and who, therefore, perform their tasks badly.

2. In the military, the willingness to accept the responsibility of making decision leads logically to:

    a. the need for deep self-study, clear thinking, and constant personal development.
    b. more and more levels of subordinates so that a leader needs to make only a few decisions.
    c. more and more leaders making decisions.

3. Moral rules must be:

    a. written in legal form to be binding.
    b. dictated by one's direct superior.
    c. demonstrated in what one does.

4. The Navy believes that:

    a. each assignment is important enough to be done with full dedication.
    b. the petty officer and officer's jobs are more important than those done by an enlisted person.
    c. it is more important to perform well in a combat situation than in a peacetime situation.

5. The Naval leader must insist that each:

    a. task be done well, that each be assigned a priority, and that each be assigned a proper amount of time for completion.
    b. task be completed exactly as assigned no matter how long it takes.
    c. subordinate has a chance to do every job.

6. The leader is:

    a. continually trying to build upon and beyond current abilities.
    b. trying to sharpen skills already acquired without trying to add new ones.
    c. unwilling to take information from subordinates.

7. Initiative combined with:

    a. knowledge is successful.
    b. get up and go is successful.
    c. physical strength is successful.

8. Courage is developed:

    a. only in a battle situation.
    b. as we work our way through everyday situations.
    c. a dramatic trait which only a few people are capable of possessing.

9. There is nothing more important in leadership than:

   a. setting a fine example.
   b. being sure you know what you want others to do.
   c. telling others what is best for the organization.

10. A leader:

   a. is perfectly prepared for each new assignment.
   b. knows that he will not be perfectly prepared for each new assignment.
   c. refuses assignments that seem too difficult.

TRUE OR FALSE QUESTIONS:

T F

1. Although leaders do not all behave alike, they all do some things similarly. ___ ___

2. A leader is interested in helping all others do their job better. ___ ___

3. A leader is interested in making a firm decision based on either real or pretended knowledge. ___ ___

4. All real success depends on personal honesty and integrity. ___ ___

5. The greatest test of loyalty for the educated person is the ability to see weaknesses in a project or organization and still remain loyal for good reasons. ___ ___

6. The leader should put an order of importance on each task. ___ ___

7. A leader must be continually interested in self-development. ___ ___

8. It is not very important to know the history of a problem and the past attempts to solve it. ___ ___

9. A good definition of courage is "acting in spite of your fear." ___ ___

10. A Naval leader fully believes in the saying "Do as I say, not as I do." ___ ___

VOCABULARY SKILLS:

Define the following vocabulary words. Complete the sentences below. There is only one correct, appropriate word for each blank space.

academic
informed
integrity
priority
calculated

1. Admiral Mitscher was a leader of great ____________________.

2. His first ________________________ was saving the lives of his fliers.

3. A good petty officer must try and stay fully ______________________ of his subordinates' problems.

4. Mitscher failed one subject in his ____________ work at the Academy.

5. Every leader understands the need sometimes to take ______________________ risks.

BRAIN TEASERS FOR CLASS DISCUSSION:

1. List as many leadership traits as you can which you believe are necessary for the President of the United States. Then try and cite situations in which the President might have to use each trait.

2. What do you feel your NJROTC instructors obligations are to you? What are your obligations in return to the instructor; to the program? Do you think there is a difference?

3. Read newspapers, magazines, or historical biographies. Find illustrations of leadership. Identify and explain what leadership characteristics are illustrated.

4. Interview coaches, teachers, guidance counselors, businessmen, or policemen for stories illustrating loyalty, courage, integrity, dedication, and ethical behavior. Make a report to the class.

THE CODE OF CONDUCT

** The Code of Conduct states in written form the behavior required of American military personnel should they become prisoners. **

In previous paragraphs, we have been discussing how a successful leader behaves. In a war situation, leaders are put under the most severe tests. It is certainly harder to be an example when you are far away from the familiarity of home. It is even harder if you are captured and the enemy systematically attempts to strip away your personal dignity and sense of loyalty.

This is exactly what happened during the Korean War (1950-1953) and later during the war in Vietnam (1962-1972). In both conflicts, the enemy extended the war right into the prison camps. An officially approved system designed to weaken moral and physical strength of the American prisoners of war was practiced by the enemy. The enemy wished to destroy the American's sense of comradeship and pride in their country. American prisoners were subjected to long hours of "brainwashing" and physical torture during which the enemy insisted that America was evil and that democracy was a lie.

When a prisoner of war was weakened by torture, threats, lack of food and sleep, he was more likely to sign "confessions" about his and America's "crimes" which the enemy then used as propaganda throughout the world. Despite the enemy's inhumanity, the loyalty of only a small number of Americans' was successfully broken. For the most part, Americans conducted themselves courageously and honorably. But it was clear after Korea that the enemy had managed to break the strength of some Americans. To make absolutely clear the high moral conduct expected of all American military, the Code of Conduct was approved by President Eisenhower on August 17, 1955. It was again approved in 1964 and reaffirmed in 1977 after President Carter amended the fifth article. Notice that at its center, in Article IV, is an emphasis on devoted leadership and mutual loyalty. These are taken to be central to survival. Under conditions of stress, soldiers must have an example to follow. Rank in the United States military obligates the officer to provide this example. This is what the duty of rank is all about.

ARTICLE I

I am an American fighting man. I serve in the forces which guard my country and our way of life. I am prepared to give my life in their defense.

** Meaning of Article I ** All men and women in the Armed Forces have the duty at all times and under all conditions to oppose the enemies of the United States and support its national interests. In training or in combat, alone or with others, while avoiding capture or as a prisoner of war, this duty belongs to each American defending our nation.

ARTICLE II

I will never surrender of my own free will. If in command, I will never surrender my men while they still have the means to resist.

** Meaning of Article II ** As an individual, a member of the Armed Forces may never voluntarily surrender. When alone and no longer able to attack the enemy, the American soldier has a duty to get away and rejoin friendly forces. Only when getting away is impossible and more fighting would lead only to death with no real loss to the enemy should one consider surrender. With all reasonable means of resistance used up and with certain death the only alternative, capture is not dishonorable. While a commander's outfit has the power to fight and evade the enemy, it has the obligation to do so. When isolated, cut off, or surrounded, a unit must continue to fight until relieved or able to join with friendly forces.

ARTICLE III

If I am captured I will continue to resist by all means available. I will make every effort to escape and aid others to escape. I will accept neither parole nor special favors from the enemy.

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** Meaning of Article III ** The duty of a member of the Armed Forces to use all means to resist the enemy is not lessened by being captured. Under the authority of the senior official (often called the senior ranking officer, or "SRO") a prisoner of war (POW) must be prepared to escape whenever the opportunity presents itself. As a matter of conscious determination, a POW must plan to escape, try to escape, and assist others to escape. In a POW compound, the senior POW must consider the welfare of those remaining behind after an escape.

Since 1950, enemies engaged by U.S. forces have regarded the POW compound as an extension of the battlefield. In doing so, they have used a variety of tactics and pressures, including physical and mental mistreatment, torture and medical neglect to try and use POWs for propaganda purposes, to get military information, or to break down POW organization, communication and resistance. Such enemies have attempted to trick American POWs into accepting special favors in exchange for statements, acts or information. Unless it is necessary to the life or welfare of that person or another prisoner of war or the success of efforts to resist or escape, a POW must neither seek nor accept special favors. One such "favor" is called parole. Parole is a promise by a prisoner of war to a captor to do something--such as agreeing not to escape nor to fight again once released--in return for favors such as relief from physical bondage, or improved food and living conditions. It might also be the promise of being released ahead of the sick, injured, or prisoners who have been there longer. Unless specifically directed by the senior American prisoner of war at the same place of captivity, an American POW will never sign nor otherwise accept parole.

ARTICLE IV

If I become a prisoner of war, I will keep faith with my fellow prisoners. I will give no information nor take part in any action which might be harmful to my comrades. If I am senior, I will take command. If not, I will obey the lawful orders of those appointed over me and will back them up in every way.

** Meaning of Article IV ** Informing, or any other action to the harm of a fellow prisoner, is horrible and forbidden. Prisoners of war must not help the enemy identify fellow prisoners who may have knowledge that is valuable to the enemy. If the enemy were to find out about such knowledge, those prisoners could be made to suffer harsh questioning. Strong leadership and communication are essential to discipline. Discipline is the key to camp organization, resistance, and even survival. Personal cleanliness, camp sanitation, and care of sick and wounded are very important. Officers and noncommissioned officers must continue to carry out their responsibilities and exercise their authority in captivity. The senior individual, regardless of Service, must accept command. This responsibility, and accountability, must not be avoided. If the senior is hurt or is otherwise unable to act, the next senior person must assume command. The responsibility of subordinates to obey the lawful orders of ranking American military personnel does not change in captivity.

ARTICLE V

When questioned, should I become a prisoner of war, I am bound to give only name, rank, service number, and date of birth. I will make no oral or written statements disloyal to my country and its allies or harmful to their cause.

** Meaning of Article V ** When questioned, a prisoner of war is required to give name, rank, service number (social security number) and date of birth. The prisoner should make every effort to avoid giving the captor any more information. The prisoner may talk with captors about matters of health and welfare and also may write letters home. Actions every POW should resist include making oral or written confessions and apologies, answering written questions, giving personal histories, creating propaganda recordings, broadcasting appeals to other prisoners of war, giving any other material readily usable for propaganda purposes, criticizing themselves, communicating on behalf of the enemy to the harm of the United States, its allies, its Armed Forces, or other POWs. Every POW should also recognize that any confession signed or any statement made may be used by the enemy as a false evidence that the person is a "war criminal" rather than a POW. Once a POW is labelled a "war criminal" the individual gives up all rights until a prison sentence is served. Experiences of American prisoners of war have proved that, although enemy questioning sessions might be harsh and cruel, one could resist brutal mistreatment when the will to resist remained.

But if a prisoner does give up information when he is under stress, it is very important for that prisoner's peace of mind and survival to make an effort to recover his courage and dedication, and not give up any additional information. The best way for a prisoner to keep faith with country, fellow prisoners and self is to provide the enemy as little information as possible.

ARTICLE VI

I will never forget that I am an American fighting man, responsible for my actions, and dedicated to the principles which made my country free. I will trust in my God and in the United States of America.

** Meaning of Article VI ** A member of the Armed Forces is always responsible for his personal actions. A member of the Armed Forces who is captured has a continuing obligation to resist and to remain loyal to country, Service, unit and fellow prisoners. The life of a prisoner of war is hard. Each person in this hard situation must always keep hopeful, and must resist enemy brainwashing. Prisoners of war standing firm and united against the enemy will support and help one another in surviving the difficulties of prison.

The Code is a formal law, something like a written version of the internal code of leadership discussed earlier in this chapter. Notice that personal responsibility and a high set of standards are central to the Code. Most important, realize also that it is not enough to know the words of the Code; as with all other real strength, it is important to understand the ideas and principles that are behind the Code. Sailors must judge whether they have been loyal to the Code's standards:

(1) total dedication to the principles of American democracy as a way of life (self-respect and personal responsibility)

(2) resistance against the enemy while resistance is possible

(3) if captured, continued resistance against the enemy and continued dedication to the principles of American democracy

(4) total loyalty to comrades-at-arms

(5) continued obligations of command

(6) under questioning, resistance to any questions other than name, rank, service number, and birth date.

The American soldier, sailor, airman, or marine is reminded by the Code that they are to behave as dedicated American citizens. An American's responsibilities are heavy but the freedoms given us by democracy depend upon our exercising those responsibilities.

MULTIPLE CHOICE QUESTIONS:

1. In both the Korean War and the war in Vietnam, the enemy:

   a. respected international rules of imprisonment, and treated prisoners fairly and equally.
   b. outnumbered American troops by 5 to 1.
   c. used an unlawful system designed to weaken the moral and physical strength of American prisoners of war.

2. For the most part American prisoners of war:

   a. broke under the pressures applied by the Communists.
   b. conducted themselves courageously and honorably.
   c. attempted to escape from the prison camps in large numbers.

3. The center of the Code of Conduct is:

   a. an emphasis on reasonable cooperation with the enemy.
   b. on the need for each prisoner to survive on his/her own.
   c. on devoted leadership and mutual loyalty.

4. Article I of the Code stresses:

   a. the prisoner's need to try and escape.
   b. the duty of all men and women in the Armed Forces to oppose the enemies of the United States.
   c. the need for all men and women to cooperate if captured.

5. The meaning of "parole" in Article III of the Code is:

   a. a promise by a prisoner of war to a captor to fulfill certain conditions, like agreeing not to escape, for favors such as relief from physical bondage.
   b. early release from prison so that the prisoner may return to serve his unit.
   c. a word meaning the misfortune of captivity.

6. The senior in a prisoner of war camp must:

   a. accept command, regardless of Service.
   b. accept command of those subordinates only in his/her Service.
   c. not accept command unless holding the rank of lieutenant or above.

7. When questioned, a prisoner of war is required to:

   a. give name, rank, service number and date of birth.
   b. cooperate with the enemy as seems reasonable.
   c. give information as long as that information does not seem harmful to one's comrades.

8. Any confession or statement signed by a prisoner of war:

   a. is allowed if it does not seem harmful.
   b. may be used by the enemy as false evidence that the prisoner is a "war criminal."
   c. is the best way to secure quick release.

9. The best way for a prisoner to keep faith with country, fellow prisoners, and self is to:

   a. agree upon a prison policy that will not anger the camp commander.
   b. provide as little information as possible to the enemy.
   c. give obviously false and misleading information.

10. The Code of Conduct was written because the military realized that:

   a. during the Korean War, the enemy had managed to break the strength of some Americans.
   b. most American soldiers did not care about their obligations.
   c. the Code would lessen the obligations of American soldiers.

TRUE OR FALSE QUESTIONS:

		T	F
1.	The Code of Conduct was first approved by President Eisenhower.	__	__
2.	The center of the Code is Article IV.	__	__
3.	All men and women in the Armed Forces have a duty at all times and under all conditions to oppose the enemies of the United States.	__	__
4.	One can surrender to the enemy if conditions suggest that the enemy can no longer be beaten.	__	__
5.	When cut off or isolated, a unit may surrender.	__	__
6.	"SRO" is the abbreviation for Senior Resource Officer.	__	__
7.	The duty of an Armed Forces member is lessened by captivity.	__	__
8.	Discipline is the key to camp organization.	__	__
9.	If a senior is hurt, it is the duty of the next senior person to assume command.	__	__
10.	The Code is a formal law.	__	__

VOCABULARY SKILLS:

Define the following vocabulary words. Complete the sentences below. There is only one correct, appropriate word for each blank space.

acccuntability

bondage

comrades

evade

mutual

propaganda

voluntarily

1. The American prisoners of war became ________________.
2. The sailors ______________ agreed to go on the mission.
3. Their ________________ was made bearable by realizing that one day they would be free.
4. Signed statements could be used by the enemy as ______________.
5. The sailor continued to be clever and to ______________ the questions.
6. The petty officer and his subordinates' relationship was based on ______________ trust.
7. The petty officer explained that each recruit was ______________ for his/her actions.

BRAIN TEASERS FOR CLASS DISCUSSION:

1. Which article(s) of the Code do you believe would be the most difficult to obey? Why?
2. In what ways do you believe the enemy might attempt to weaken one's will?
3. Why is it important to understand the ideas and principles that are behind the Code rather than just memorize the Code and know it by heart?

DISCIPLINE: TWO VIEWS

** One kind of discipline is a result of raw fear. Another is the result of understanding. **

One kind of discipline we see comes about as a result of raw fear. A dog crouches with its tail between its legs as its master raises his voice and shouts, "Get out of the kitchen"! The dog goes, remembering severe beatings in the past that have accompanied these sounds. The animal responds because it fears being harmed. Probably, if given the smallest opportunity, it will bite its master. In Hitler's dictator-led armies this kind of unthinking discipline was common and eventually his own generals tried to "bite" him to death.

But the United States works from a different set of ideas. We believe that citizen-soldiers will be disciplined because they understand the good reason for self-control and are dedicated to the principles of democracy.

When you stop and think about it, democracy is based on well thought-out self-discipline. An American citizen is expected to go to the voting polls without being forced. He/she is expected to have learned about the candidates and the issues and to have made a careful decision about them. Voting records these decisions. These recorded votes determine the directions of government--its laws and elected lawmakers. Clearly, the democratic process trains us to expect well thought-out self-discipline. If citizens in a democracy were to stop going to the polls and stop exercising their right to make self-governing laws, democracy would end.

Our system of laws is set up to protect every individual in the society. Clearly again, no individual has a right to break the law without suffering just punishment because in so doing he is inflicting harm on someone else and this is not to be tolerated in a democracy. We agree on laws; we agree to vote for the most qualified leaders and in doing so, we agree upon reasonable protection and safety for the whole population. The key word here is "agree." It means we have thought about and decided upon the system by which we want to live.

Conscientious American soldiers, sailors, airmen and Marines will respond to a leader's order because they understand it is necessary for the general good. They will respond because they've come to understand that it is their duty to protect a uniquely free way of life and that discipline (agreed upon order) is necessary to efficiently accomplish each task which contributes to the general mission. They will respond to the needs of a situation because they understand it requires response--not because they fear punishment. The definition of military discipline might be "that degree of control which moves an organized group to appropriate action upon receipt of an order, or in anticipation of that order when circumstances prevent its being given."

The second part of the above definition is most interesting; it says that the people in our Armed Forces will so respect the need to accomplish the task that they will push on even if the designated leader is temporarily absent. They will pursue their mission as if the leader were present. Overall, they will respond to a leader's orders in much the way the fine athlete will respond to the coach's directions--because they have come to respect his judgment which they know is based on firm knowledge. When the coach and the leader set an example worth following, followers, and often even seniors, recognize, respect, and respond. The response may not always be in exactly the way the leader expected, but it will be in the desired direction. It is the leader's job to build that response. Every person wants to know that their efforts are appreciated. A leader's word of advice to new men and women, a look of approval after an exceptionally good drill, yes, and even recognition for the accomplishment of what seems to be the most "unimportant job" will clearly show that the leader is noticing honest effort. A leader's actions show he/she believes that in the service of one's country there are no small jobs.

For extraordinary effort, a leader should give public recognition and, if warranted, official recognition. The Navy system officially recognizes outstanding effort by promotion. But, of course, all grades of recognition are only meaningful if they are earned. In school, a grade made too easily is not respected or appreciated by the receiver; praise or promotion earned too easily produces the same results.

AN OFFICER AND PERSONNEL

** Honest, intelligent, continuing concern for personnel is crucial to the behavior of the effective officer or petty officer. **

Every person wants to feel important. The simple point is that in the Navy every person is important and the petty officer should make this clear. How? By showing honest interest in and concern for each junior not only because such understanding will make for more accurate assignment of proper tasks but because it is the legal and moral duty of the officer to try and ensure the safety of personnel. And safety, after all, is emotional and mental as well as physical health. If juniors have severe personal problems they will not do their jobs with care. It is the petty officer's duty to help the subordinate understand the problem and come to grips with a solution. Honest, intelligent, continuing concern for one's personnel is crucial to the behavior of the effective officer or petty officer. Concern implies that the leader supports his/her subordinates. In a sense, it also means the petty officer wishes to be their friend if "friendship" means mutual affection based on respect for the jobs that both need to accomplish. The petty officer must always remember that with rank comes the responsibility of setting the best possible example. This means not only being approachable for advice but worthy of giving it. Rank must mean responsible friendship. It cannot mean familiarity. It cannot mean being buddies with subordinates. The reason is simple. The petty officer must always be seen in a position of reliable authority. The petty officer must be someone that can be looked up to.

The line between friendship and familiarity sometimes might seem to be thin, but the petty officer, for the good of subordinates, and, of course, of the organization, must be able to draw that line.

DISCIPLINE WHEN SELF-DISCIPLINE FAILS

** The petty officer must make it clear that failure to respect regulations will be handled immediately, justly, and without anger. **

In civilian life we make laws to protect each citizen's rights and to protect our collective rights. But in every society, we will have breakdowns. Our laws allow us to deal with these. When someone is accused of breaking the law, our system assumes that the accused is innocent until proven guilty. If proven guilty, the criminal still has the right to expect quick, fair, and consistent treatment under the law. Our system has done pretty well in providing such treatment.

In the Navy, we assume that all personnel wish to follow regulations and to keep discipline for the general good. But we know that there will be some breakdowns. A petty officer must make his/her position about failures to respect regulations clear: the failures will be handled immediately, justly, and without anger. The officer must also make it clear that each person will be treated as fairly as possible. Each case will be individually reviewed according to its peculiar set of circumstances. No favoritism, no overreaction will be shown. The petty officer must show subordinates that when and if they are not dependable, he/she will be.

LOSS OF TEMPER = MUDDIED THINKING

** Anger clouds thought. **

No petty officer can afford to lose his/her temper. Of course, anger is about as human as we get. But, like all violent emotions, anger clouds thought. And the petty officer's duty requires clear thought; it requires the constant attempt to teach subordinates. Anger is no substitute for the officer's careful analysis of a subordinate's error. The officer must keep in mind that he/she wants to prevent the error from occurring again. And the best way to do this is not by blowing one's top but by analyzing the error and its consequences. A petty officer sets an example by remaining calm, analytical, and dedicated to the idea that each job must be done intelligently and efficiently. The petty officer's reaction to all situations, including errors, sets the tone that the rest of the personnel will follow.

SUMMARY: LEARNING TO ACCEPT COMMITMENT AND RESPONSIBILITY

** The commitment of being in the American military also demands learning to accept responsibility. **

When a person enters the Navy, an oath is taken. In the oath that person swears to uphold and defend the Constitution of the United States against all enemies. In reality, the sailor swears to defend the principles and privileges of freedom and self-determination passed on through a long chain of command starting in the individual citizen of the United States. An American sailor is swearing to defend his/her own rights and responsibilities. The sailor swears to faithfully discharge each assigned duty. Each performed duty--no matter how small-- must be seen as dignified and important because each is part of the defense of individual freedoms. The sailor is swearing to try and be the best, most informed, responsible citizen-soldier possible. Thomas Jefferson said, "There is no safer depository of the ultimate powers of the society but the people themselves." The American citizen who has sworn the oath of service has taken on an additional responsibility of democracy.

When an especially well-qualified person becomes a petty officer he/she takes on added authority and also added responsibility. The person says to the nation, "I can responsibly lead others in protecting the United States." But the very others led are a part of the citizenry that gives the petty officer his/her authority. This is a complicated role. In order to best fulfill his/her role, it is the individual's moral and legal duty to continually work at self-improvement.

The petty officer must work toward developing professional skills, improving abilities to train, guide, and insure the well-being of subordinates. In all activities the petty officer must set the example; the petty officer must acknowledge this obligation.

MULTIPLE CHOICE QUESTIONS:

1. In Hitler's dictator-led armies, discipline inspired by fear led to:

   a. his generals trying to murder him.
   b. the battle of Stalingrad.
   c. desertions.

2. Conscientious soldiers, airmen, and Marines will respond to a leader's order because they:

   a. fear punishment if they do not respond.
   b. wish to be rewarded for loyal behavior.
   c. understand it is necessary for the general good.

3. Dedicated people in our Armed Forces will:

   a. respond, even if the designated leader is temporarily absent.
   b. take no action unless the designated leader gives an order.
   c. always respond exactly to the leader's expectation.

4. The leader believes that in the service of one's country:

   a. most small service jobs are relatively unimportant.
   b. every job requires public recognition.
   c. there are no small jobs.

5. A petty officer's definition of "friendship" to his/her subordinates should be:

   a. mutual affection based on respect for the jobs that both need to accomplish.
   b. personal affection that passes over disagreements about official responsibility.
   c. fellowship and familiarity.

6. A petty officer should handle failure to respect regulations:

   a. by reporting these to the Chief Petty Officer.
   b. immediately, justly, and without anger.
   c. by immediately chewing out the offender in public.

7. A petty officer's anger at a subordinate's error:

   a. shows concern for the unit's welfare.
   b. clouds accurate thought.
   c. should precede any analysis for the error and its consequences.

8. All military personnel swear an oath to:

   a. uphold and defend the Constitution of the United States against all enemies.
   b. uphold the Geneva Convention.
   c. read and understand the words of Thomas Jefferson.

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9. No individual has the right to break the law:

    a. without suffering just punishment.
    b. unless he is officially representing a government agency.
    c. unless the law seems too severe.

10. When the leader sets an example based on firm knowledge and clear thinking:

    a. followers, and often even seniors, recognize this and respond.
    b. followers will always respond.
    c. every person will want his efforts recognized.

TRUE OR FALSE QUESTIONS:

		T	F
1.	A petty officer shows little interest and concern for juniors because they are assigned unimportant jobs.	___	___
2.	Military personnel will respond to the needs of a situation because they understand that it requires a response.	___	___
3.	For extraordinary effort a leader should give public recognition.	___	___
4.	In order to keep subordinates happy, praise and/or promotion should be offered freely and easily by the petty officer.	___	___
5.	A definition of military discipline might be "that degree of control which moves an organized group to appropriate action upon receipt of an order, or in anticipation of that order when circumstances prevent its being given."	___	___
6.	The petty officer must be able to draw the line between friendship and familiarity.	___	___
7.	A petty officer's response to errors sets a model for his subordinates.	___	___
8.	In a sense, the American sailor swears an oath to defend his/her own rights and responsibilities.	___	___
9.	One kind of discipline results from fear of punishment; the other is the result of understanding.	___	___
10.	Voting is the way Americans record their decisions about candidates and issues.	___	___

VOCABULARY SKILLS:

Define the following vocabulary words. Complete the sentences below. There is only one correct, appropriate word for each blank space.

designate

familiarity

inflict

personnel

privilege

tolerated

1. Breaking regulations can not be __________ by a petty officer.
2. The officer called a meeting of all __________.
3. The enemy decided that the best way to break the prisoner's will was to __________ pain.
4. With the __________ of rank comes its responsibility.
5. There is a basic difference between professional friendship and __________.
6. She asked that the petty officer __________ her for the mission.

BRAIN TEASERS FOR CLASS DISCUSSION:

1. If anger is human but not desirable, what are some alternate ways that a petty officer can deal with anger?
2. Can you set up a list of differences between reasonable and unreasonable discipline? In what practical situations might a petty officer have tc administer discipline?
3. Why is it important for a petty officer to study his/her personnel?

CHAPTER III: METEOROLOGY

KNOW THE WEATHER

** The age of exploration took place in the 15th, 16th and 17th centuries. **

INTRODUCTION

In all the natural world, weather is outstanding in its beauty, its majesty, its terrors and its continual direct effect on us all. Because weather involves, for the most part, massive movements of invisible air and is concerned with the temperature and pressure changes of this almost intangible substance, most of us have only a limited understanding of what weather is all about. This chapter will help you to understand it and also to understand, in some degree, how weather changes are predicted.

Since the modern Navy travels to the farthest corners of the world, over and under the sea, as well as through the air, sailors know that the success of a voyage depends on being ready for anything, including weather. In fact, major events in modern American Naval history have been changed by the weather. During World War II, the Allied invasion of Normandy was delayed by the weather. The British, who have always lived with the Atlantic storms, built special portable, floating harbors for the Normandy landing. They knew the Atlantic waters off the Normandy coast would be storm-tossed. In the Philippines, American Marines had to fight not only the Japanese but the hot, humid weather as well.

And many United States troops were injured in the Northern Aleutian Islands, not by the enemy, but by the bitter cold.

Voyagers have been fighting the weather since the earliest Greeks. But, in more modern times, when more men began traveling farther and farther away from home, they started to realize the need for correctly measuring and, therefore, predicting the weather.

AN AGE OF EXPLORATION

This age of exploration took place in the late 15th, 16th, and 17th centuries. Columbus, in 1492, was part of man's adventure to find a new world. At the same time, scientists began exploring. They explored the inner world of man's body and the world outside his body -- the universe.

In the 15th century, Leonardo da Vinci, a great scientist and artist, invented the hygrometer (hygro means wetness and meter means measure). The hygrometer is an instrument which measures wetness in the air. Leonardo weighed a ball of dry wool on both a dry and a damp day. The ball weighed more when the weather was wet. This seems simple now, but remember that in the 15th century few people had even thought about accurate proof about the weather by experimenting. So this was a very important scientific discovery. Leonardo da Vinci proved that there is invisible wetness in our air all around us.

Anyone who has ever run in the hot, dry atmosphere of Arizona or the hot, wet atmosphere of Florida knows how differently these two atmospheres feel. Even though the air looks the same, it is very different. The word atmosphere comes from the Greek word "atmos" which means vapor. The Greeks guessed that much of the air was water in the form of a gas. But da Vinci went much further by scientifically observing and measuring the amount of water vapor in the air.

Probably the most important scientist of the exploring age was an Italian, Galileo Galilei. He lived in the middle of the age (1564-1642). He was a great genius and made many discoveries. He was the first man to use the telescope to explore the sky. He proved that the earth revolved around the sun. With this idea he shook the world's beliefs. Up until his discovery people had believed that the earth was the center of the universe.

As part of Galileo's scientific explorations, he invented the first simple thermometer (thermos means heat). Galileo said that the only way man could understand his world was by carefully observing it first. He also said that measuring heat was a very important first step in understanding the weather. He was right.

Galileo's thermometer can be thought of as the first giant step forward in modern meteorology, the scientific study of the atmosphere.

The barometer was invented about the same time as the thermometer (1643). The barometer measures the weight of the air above us. Air having weight is a hard idea to understand. Air seems empty and without weight. But it isn't. Air has weight like every other substance in our world.

Still another weather instrument was invented at this time. This was the anemometer (anema means wind). The simplest anemometer you've seen is the weather vane. Mounted on a barn's roof, the vane (in the shape of a rooster) can turn freely with the wind. It is blown in the wind's direction.

Knowing more about the weather became increasingly important in modern history when navies and armies fought thousands of miles away from home. Troops were being moved into areas of the world with different weather conditions and patterns. Being prepared or unprepared for those conditions would mean life or death.

Just before World War II Vilhelm Bjerknes, a Norwegian meteorologist, developed an idea of how to explain worldwide weather patterns. This idea was based on air masses and polar fronts. An air mass is simply a huge bubble of cold or warm air traveling over the earth's surface. A polar front is a very cold air mass, sweeping down over the earth from the North or South Pole. Air masses coming together make up weather patterns.

During the war, many weather observation stations were set up all over the world. These stations would take measurements and send in their reports. As a result, large scale weather forecasting was made easier. Commanders could know what kind of weather their troops could expect.

As aviation developed, meteorology also developed. Pilots could get closer to storms and send back more accurate information.

There are even hopes now of finding ways to change or control the weather for man's welfare. So far these have not been very successful, but meteorologists are still experimenting.

MULTIPLE CHOICE QUESTIONS:

1. The scientific study of the atmosphere is called:
   - a. astrology.
   - b. meteorology.
   - c. biology.

2. The thermometer was invented by:
   - a. Galileo.
   - b. Leonardo da Vinci.
   - c. Columbus.

3. The invention of the thermometer was the first:
   - a. major invention.
   - b. giant step forward in modern meteorology.
   - c. invention by the Greeks.

4. The gaseous form of water is called:
   - a. dew.
   - b. vapor.
   - c. oxygen.

MATCH THE FOLLOWING:

_____	1.	hygrometer	a.	Television and Infra-Red Observation Satellite
_____	2.	thermometer	b.	a cold air mass
_____	3.	barometer	c.	measures wind
_____	4.	anemometer	d.	measures weight of air
_____	5.	air mass	e.	measures heat
_____	6.	polar front	f.	measures wetness in air
_____	7.	TIROS	g.	a huge bubble of cold or warm air traveling over the earth's surface.

BRAIN TEASERS FOR CLASS DISCUSSION:

1. Use an encyclopedia or a reference book on meteorology to find out what the following instruments look like: anemometer, wind vane, rain gauge, and ceilometer. What conditions of the atmosphere do these instruments measure? Where is each instrument used, in a laboratory station or outdoors? Find out how each instrument works.

2. Find out how some other weather instruments work.

3. Describe the climate where you live. Explain how it affects business, farming, clothing, transportation, housing and recreation.

4. Visit a weather station. Describe the following instruments: wind vane, barometer, thermometer, hygrometer, anemometer.

5. Make a report to the class telling how radar and satellites are used in forecasting the weather.

6. Make a simple wind vane, anemometer and hygrometer. Demonstrate how each works.

THE ATMOSPHERE

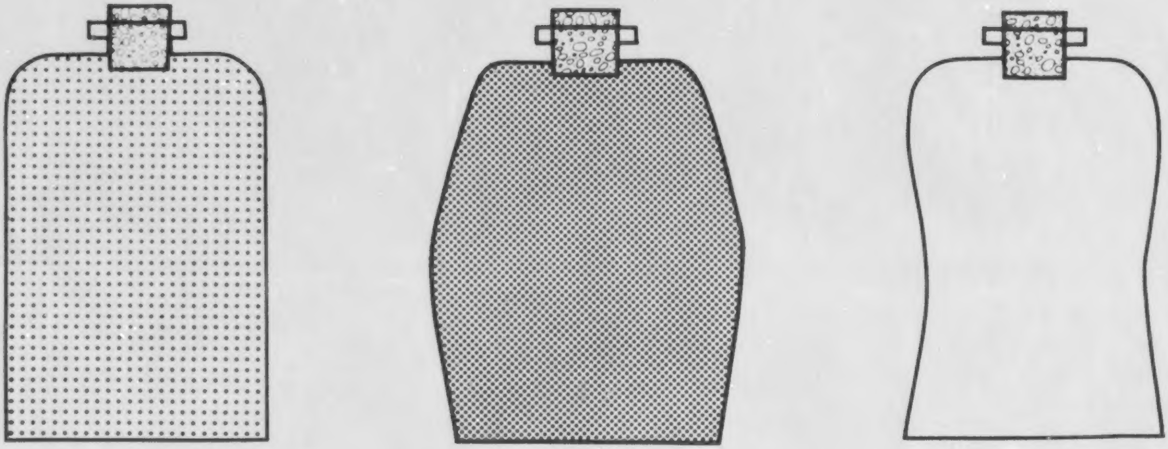
** The atmosphere is divided into four major layers. Conditions in the troposphere, the layer closest to the earth's surface, determine the earth's weather. **

We know that large parts of the earth's surface are covered by water -- oceans, lakes, rivers. The deeper the water, the more pressure there is at the bottom. Submarines cannot descend below certain depths, or they will be crushed by the pressure. We also live in an ocean of air, which covers the whole earth. This ocean of air is about 1,000 miles deep. We are at the bottom of this air ocean, and the pressure down here is greatest. It becomes less as we go upward. We begin to notice the difference by just climbing a mountain. The pressure is less higher up and we begin to feel lightheaded. The lightheadedness is also because there is less oxygen mixed into the air the higher we go. This vast ocean of air is our atmosphere.

The air is a physical mixture of gases, something like coffee and cream mixed together. The main gases of the air closest to the earth are nitrogen (78%) and oxygen (21%). Of course, we need oxygen in order to breathe. The other 1% is a mixture of argon, carbon dioxide and tiny traces of neon, helium, krypton, and xenon. At any height up to about 125 miles, over any region of the earth, there is about the same mixture of oxygen and nitrogen. It does not matter whether the air is calm or disturbed.

The atmosphere also contains water vapor. Water vapor is very important in making weather because unlike the gases, the amount of water vapor (humidity), in the air is different from one place to another. Also, how the water vapor is heated by the sun affects weather. In short, the water vapor in our air + heat make our weather.

The amount of water vapor the air will hold depends on the air's temperature. Warm air will hold more water vapor than cold air. There is more water vapor over the equator than over the poles. Is it hard to picture separate masses of air, each containing separate amounts of water? In order to make the picture clearer, try this. In your mind make up a gallon jug of air. Construct the gallon container of flexible and stretchable material (figure 3-1). Then think that the gallon will stretch larger when heated and shrink when cooled. Like the gallon jug, the hotter the air, the more water it can hold. Like any other jug, there will finally be an upper limit to the amount of liquid this jug can hold.



One Gallon of Cool Air
100% Relative Humidity

One Gallon of Warm Air
100% Relative Humidity

One Gallon of Dry Air
No Humidity

Figure 3-1. Flexible Gallon Jugs of Air

When any parcel (amount) of air is 100 percent soaked with water vapor we say there is 100 percent humidity. When a parcel of air has only 50 percent (or 1/2) of the amount of water vapor it can hold we say the air has a relative humidity of 50 percent. Relative humidity is a percentage of the amount of vapor the air can hold at a given temperature. Both cool and warm air can have 100 percent relative humidity (figure 3-1). Of course, the relative humidity depends on the air's temperature. If a mass of hot air is suddenly cooled, it will shrink, and will be less able to hold the water. In other words, its relative humidity will go up. When a parcel of air in nature reaches 100 percent relative humidity and can hold no more water vapor, we get rain or fog.

Dew drops on grass in the early morning are another way of understanding relative humidity. In the morning the air is usually cool. The relative humidity is high (100 percent) and the air delivers its water vapor to the surface of the grass leaf. As the sun comes out, the air warms, and the air is more able to hold water. The dew drops evaporate back into the air and the grass leaf is dry.

Although we cannot see it all the time, water surrounds us as much as it surrounds "water creatures" like the sharks and porpoises. But much of our water is in a different ocean.

THE EARTH AND ITS OCEAN OF AIR

Think of the earth and its atmosphere as a huge grapefruit wrapped in layers and layers of cotton gauze. The pulp of the grapefruit is the earth. The skin, or rind, of the grapefruit is the first 3-1/2 miles of the earth's atmosphere. The cotton gauze, which gets looser and looser, is the other 996-1/2 miles of atmosphere. The skin or rind is thick; like the lowest 3-1/2 miles of atmosphere. The gauze gets increasingly thinner and looser as do the outer layers of the atmosphere. Since the air in the lowest 3-1/2 miles is thicker, the pressure here is also greater. In fact, 50 percent of the atmosphere's weight is thickly packed into these lowest 3-1/2 miles.

As we travel upward in our atmosphere and farther away from earth, the air grows much thinner and the pressure lessens. The higher up we go, the less oxygen there is in the air. It is very hard to breathe at these higher altitudes.

Also, as we go higher, the air gets colder. The colder it gets, the less capable the air is of holding water. The weather we see -- rain, fog, clouds, and snow -- occurs before we reach 20,000 feet above the earth's surface. Forty-five miles above the earth, all oxygen has disappeared. Only small amounts of helium and hydrogen exist up here.

EARTH'S ATMOSPHERE: FIVE LAYERS

The atmosphere is divided into five different layers. The five layers are: (1) the troposphere, (2) stratosphere, (3) mesosphere, (4) thermosphere, and (5) exosphere. Each of these layers has a set of special characteristics, like fingerprints (figure 3-2).

The Troposphere

The first layer, closest to the ground, is called the troposphere. The troposphere is 5 to 11 miles thick. It is thicker over the warmest places of the earth, near the equator, and thinner over the colder places, like the North and South Poles.

In other words, the troposphere is where we all live. The air in this 5 to 11 miles is constantly mixing and turning. Water vapor is trapped in this layer.

It is because the air here contains water vapor and because the air here is constantly mixing and turning that we get our different weather conditions on earth. Weather is simply the kind of air that is present in one part of the troposphere. When we say we wish the weather would change we are really hoping that a different parcel of air might arrive.

Because the troposphere traps all the water vapor, clouds form here. How does a cloud form? Let us say there is a parcel of hot wet air resting over the equator. Hot air always tries to rise. This process is called convection. As the hot air rises, it begins to cool and when it cools, the relative humidity of the air parcel increases. When the relative humidity of the air reaches 100 percent the air can no longer hold the water vapor. The water vapor condenses into tiny liquid drops and a cloud is formed.

As the hot air begins to rise, it leaves an empty space. Colder air rushes in to fill the empty space. This is a simple example of air circulation.

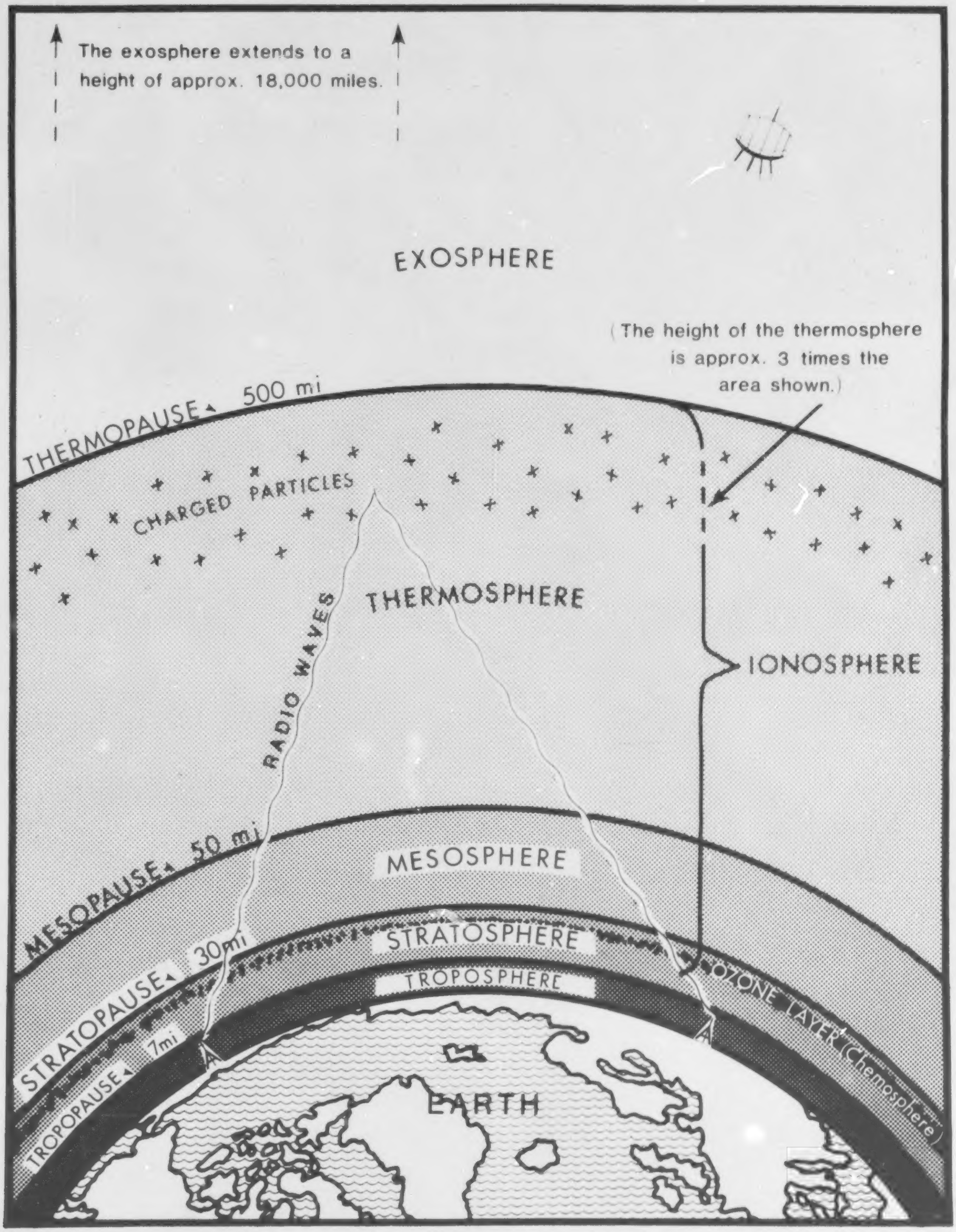


Figure 3-2. The Earth and its Five Layer Ocean of Air

The Tropopause

There is a border zone of air over the troposphere. It is called the tropopause. It is divided into three overlapping areas -- tropical, extra-tropical, and Arctic. The height of the tropopause varies. It has a height of about 10 miles at the equator where there is great heating and upward movement of the air which is created by convection. But it has a height of only about 5 miles at the poles.

There are currents of air up in the tropopause called the jet streams. These streams occur at about 20,000 to 40,000 feet and move from west to east at high speeds. Discovery of the jet streams was important to B-29 bombers during World War II because they flew at an altitude of about 4 miles. By getting into a jet stream of 300 mph, they increased speed, conserved fuel, and shortened their flight time. In a sense they could ride the stream. Of course, the bombers needed to avoid the streams on their return flight in order to avoid heavy resistance.

The Stratosphere

Just above the tropopause is the stratosphere. The stratosphere reaches an altitude of 30 miles and contains almost no water vapor. Also, the temperature is a constant -40° to -50° F. Therefore, there are no clouds and there is very little upward or downward movement of the air. It is because the air is so quiet here that modern commercial pilots like to fly in the stratosphere when not using the jet streams.

Since about 1970 scientists have started to worry about supersonic transport planes flying in the stratosphere. The scientists have shown that in the upper edges of the stratosphere there is an ozone layer. Ozone is a gas that is formed from oxygen. It is important as a protective shield for the earth because it absorbs ultraviolet rays from the sun before they can reach the earth. Too much ultra violet light causes skin cancer. Scientists point out that the jets' supersonic engines release nitrogen oxide gases in the ozone layer. These have a chemical reaction on the ozone and destroy it. Because the stratosphere has no water vapor and, therefore, no weather, the nitrogen oxide stays in the ozone for a long time. In 1975 the United States National Academy of Science made an alarming report. They said that unless the supersonics' engines could reduce the nitrogen oxides, a large fleet of these planes could destroy the earth's protective ozone layer.

Chemosphere (Ozone Layer)

A small transition zone just above the stratosphere is the chemosphere (also known as the ozone layer). It starts at 10 to 15 miles above the earth. As discussed before, it is very important for the protection it gives us against ultraviolet rays. Because we know so little about this area, scientists sometimes classify it as part of the upper regions of the stratosphere or as part of the lower regions of the next major zone, the mesosphere.

The Mesosphere

The mesosphere starts at about 30 miles and reaches an altitude of 50 miles. The temperature here goes from 30°F at 30 miles to -100° F at 50 miles. In other words, the temperature will drop 135° in just 20 miles! At about 70 miles altitude the temperature again begins to rise.

The Thermosphere

The thermosphere is the next highest layer. It is here that the air is thinnest and electrically charged. It is also here that most of the radio reflecting particles exist. It is very hot in this layer.

Collectively, the stratosphere, mesosphere, and thermosphere are known as the ionosphere.

The Exosphere

The exosphere is the highest layer of our atmosphere before outer space. It begins at 500 miles and goes up until about 18,000 miles. This must be a strange place. The temperatures here range from unbelievably hot to unbelievably cold: 4,500° F in daylight to -460° F (near absolute zero) at night.

Up here only helium and hydrogen exist. The atmosphere is so thin that if you pulled all the air molecules in a 10 mile cube together, collected them, and pulled them down to earth, they would not fill the eye of a needle! The air particles here are charged with electricity from the sun. The electrically charged particles are concentrated in two zones at about 2,400 miles and 9,600 miles. These zones are called the Van Allen radiation belts. It is only since 1958 that we have been able to use satellites to study these belts. These belts of radiation are weakest above the earth's magnetic poles. Manned space ships must go through these weak spots, called "escape zones," if they want to reach outer space. You might say that these "escape zones" are our only doors to outer space. The exosphere is the last and highest layer of our air ocean. From here we enter outer space.

STUDY QUESTIONS:

1. In the space below, diagram and label the five layers of the atmosphere.

2. Name two characteristics of each layer.

   1. ____
   2. ____
   3. ____
   4. ____
   5. ____

3. Why is the ozone layer important?

   a. it serves as a protective shield for the earth.
   b. it absorbs ultraviolet rays from the sun.
   c. both a and b.

4. The area known as "escape zones" for spacecraft is called:

   a. krypton.
   b. Van Allen Belt.
   c. troposhere.

VOCABULARY SKILLS:

Define the following words according to the definition given in the text.

1. Humidity

2. Relative humidity

3. Convection

4. Ozone layer

5. Jet stream

HIDDEN MESSAGE

___ ___ 30	Drops on grass in the early morning.
2 ___ 23 ___ ___ ___ ___ ___ 15 ___	The vast ocean of air surrounding us.
___ ___ ___ ___ ___ ___ ___ 12	The main gas in the air closest to the earth.
___ ___ 14 16 ___ 13 ___	The area on the earth that has the greatest amount of water vapor.
___ 28 ___ 17 ___ 11 ___ ___	Another name for water vapor.
___ 35 ___ ___ ___ ___ 7 3 ___ 18 ___	Relative humidity is dependent on this.
___ ___ ___ ___ 25	What you must do to solve this puzzle.
___ ___ ___ ___ ___ ___ ___ 19 ___ ___ 4	Clouds form in this layer of the atmosphere.
22 ___ ___ ___ ___ ___ ___ ___ ___ 20	The jet stream occurs here.
___ 33 5 21 ___ 9 ___ 8 ___ ___ 10 ___	The ozone layer is in this part of the atmosphere.
___ ___ 27 ___ ___ 34 ___ 29 26	The highest layer of our atmosphere.
1 24 ___ 31 ___ 6 32 ___ ___ 36	Another name for humidity.

MESSAGE:

Figure out the message by transferring the letter from the numbered blank above to the blank with the corresponding number.

1 2 3 4 5 / 6 7 8 9 10 / 11 12 / 13 14 15 / 16 17 18

19 20 21 22 / 23 24 25 26 / 27 28 29 / 30 31 32 33 34 35 36

THE WEIGHT OF THE AIR

** When we talk about the weather, we are really talking about the air's weight, wetness, movements, and heat. **

Man and other air-breathing animals can only live in the lowest 20 miles of the atmosphere. Here all of the air overhead presses down with a force of 15 pounds per square inch. Over millions of years man has learned to adapt to this pressure. This pressure is called air pressure. If man climbs high into the mountains, he realizes that the air is thinner and air pressure is slightly less. Man is so used to nearly 15 pounds per square inch, his body feels strange in higher altitudes.

Scientists weigh a column of air by using the barometer. The most common barometer uses mercury and works like an old fashioned balance scale that has a pan on either side of a cross arm. You have probably seen the balance scale. On one pan you place an object, like grapes. On the other side you place exactly measured weights until the two sides balance. Then you know exactly how much the grapes weigh (figure 3-3).

The barometer is used to find out how much a column of air weighs. The original barometer did this by taking an empty 3 foot long glass tube sealed at one end and open at the other and filling it with mercury. The tube looked like a long thin test tube. The filled tube was then turned upside down and placed into a large bowl of mercury. Then a strange thing happened. The mercury in the tube kept falling until the weight of the mercury in the tube balanced out against the weight of the air pressing on the surface of the mercury in the bowl. So the length of that much mercury in the tube was equal to the air's weight pressing down on the surface mercury in the bowl. The resulting empty space above the tube's mercury is a vacuum. This reading was taken at sea level (figure 3-4).

Scientists now knew how high the mercury in the tube rose at sea level. And so they could measure differences at other altitudes and at other times of the day. The heavier the air pressure on the outside, the higher the column would rise. When they took the barometer up to the top of a high mountain, the mercury in the tube fell. So the scientists knew that the true air pressure at higher altitudes was lower.

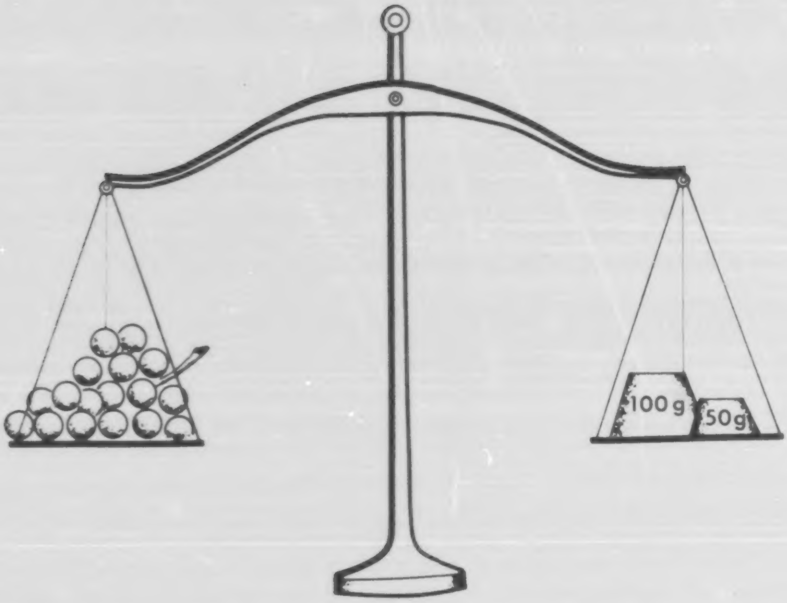


Figure 3-3. Balance Scale

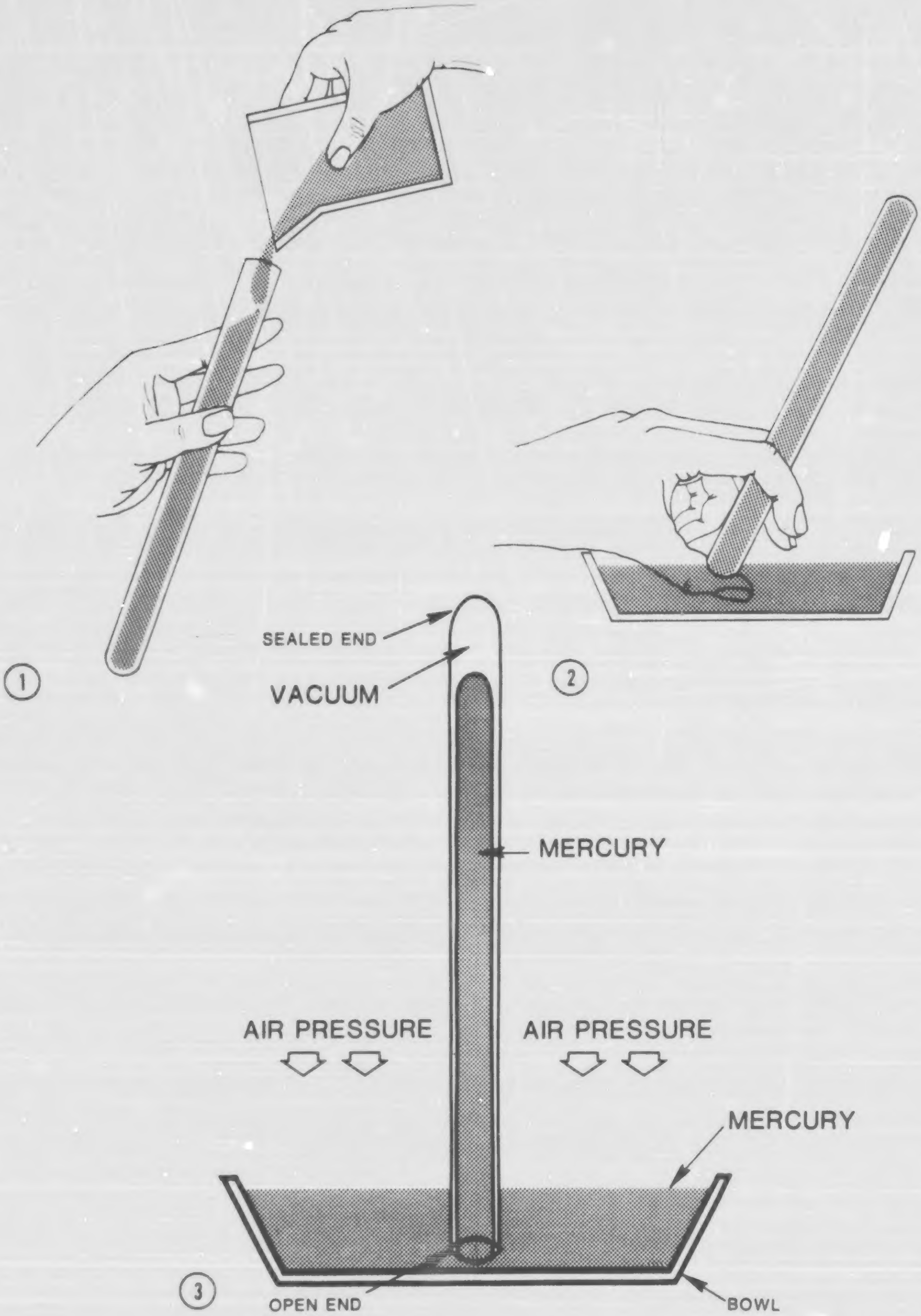


Figure 3-4. A Mercury Barometer

You would expect this to be true since you know that the higher up you go, the thinner the air is.

The barometers in use today are just improved forms of the original. The modern tube has careful measurements on it. In the United States, the barometer tube is usually marked in inches. Countries that use the metric system mark their barometers in millimeters. So if we say that the barometer measures 29.92 inches (or 760 millimeters) we are really saying that the pressure of the air supports a column of mercury which is 29.92 inches long. 29.92 inches (760 millimeters) is the normal pressure at sea latitude 45 degrees. This is called the normal atmosphere. It is also simply called one atmosphere.

There is another unit of measurement commonly used. It is called a bar. Barometer measures are sometimes marked in millimeters. A millibar is a thousandth of a bar.

The Navy uses the mercurial and the aneroid barometers. The aneroid barometer is really a flexible metal box with a vacuum inside. The box is kept from folding up under outside air pressure by a spring inside. The box responds to outside air pressure by pushing in. This movement is recorded by a hand (like a hand on a clock) which moves over a dial.

There is also a modern instrument called a barograph. It is simply an aneroid barometer that makes a continuous record of barometric pressure.

All of these different forms of the barometer record the air's weight.

THE TEMPERATURE OF THE AIR

Anyone who has gone to a picnic in the warm sunshine and run home from the same picnic in a cold rain knows that the weather changes. But how? Most of the changes in the weather are caused by changes in the temperature. Heat is the most important cause of the weather.

HOW HEAT WORKS

When you stand in front of a fireplace, you get hot. The heat you are feeling comes from the burning coals. The coals are losing their heat and it is moving through the air toward you. If someone stands between you and the fire, he will receive more of the heat. The heat he feels is radiant energy. Scientists believe that every object in the universe acts like the sun. Every object, hot or cold, can give up its energy in this way. For example, the earth is giving up some of its energy day and night. The loss is called "cooling by radiation."

The sun heats the earth. Its rays race down into our atmosphere. Some of the rays are absorbed by the gases in the atmosphere. Some hit clouds and are flipped back as if they had hit a mirror. Some almost reach the earth's crust but instead, hit the shiny dome of a building or a bridge and bounce back to the sky. And some hit the earth and are absorbed. On an average a bit less than 50 percent of the sun's incoming radiation is absorbed. The earth heats up quickly especially on sunny days. But it only heats up on its surface, about four inches deep. So the earth is a very good absorber at its surface. But it is also a good radiator. At night when the sun goes down, the earth radiates much of its stored heat back into the air.

But the heat does not go all the way upward and back into space. Instead, the water vapor in the air stops it. The water vapor acts like a one-way stop sign looking down at the earth. It holds the heat gained from the sun close to the earth and only lets the heat escape slowly. The more water in the air the more this blanket works. Farmers know this. They like moist and cloudy nights. They know that the warmth of the day will stay on this kind of night. But these same farmers fear clear, dry, cloudless nights because the warmth of a 60° F day can drop to freezing in just a few hours.

Some of the sun's rays also hit the oceans. The oceans gain and lose heat slower than the land. At night the oceans lose less heat. Of course, the air above the oceans is also much wetter than the air above the land so the ocean heat that is lost is held down more completely. The air above the oceans, then, is warmer than the air above surrounding land masses.

So we see that the sun strikes the different surfaces of the earth and is absorbed and lost at different rates. As a result, the air masses above different locations on the earth have very different temperatures.

Now it is a law of nature that warm air is lighter and cold air heavier. So warm air rises; cold air falls and flows toward the warm air (figure 3-5). The result is moving air masses (winds), the transfer of heat, and what we generally call weather. And the sun's heat is the reason for it all.

MEASURING HEAT

Since heat plays the most important part in making the weather, any observations about the weather depend on carefully measuring temperature. Temperature simply means the degree of hotness or coldness measured on a definite scale.

The thermometer is the instrument used to measure temperature. It is like the barometer in that it is a glass tube filled with liquid. But here the similarity stops. The top of the thermometer's tube is filled with air. Its liquid is alcohol or mercury. The liquid expands when it is heated; and gets thinner when it is cooled. When it expands, the liquid needs more room and so tries to escape the pressure of the sides of the tube. It goes up the tube. The opposite occurs during cooling; the liquid relaxes and moves down the tube.

Thermometers can use two different measurement scales (figure 3-6). The first is called the Fahrenheit thermometer (F). The temperature of melting ice is called 32°F and that of boiling water, 212°F. The Fahrenheit thermometer is now in common use only in English-speaking countries. On the Centigrade scale, the second measurement, the freezing and boiling points of water are 0°C and 100°C, respectively. On both the Centigrade, sometimes called Celsius, and the Fahrenheit thermometers temperatures below the zero are written with a minus sign. A change in temperature from 32 to 212, being a change of 180 on the Fahrenheit scale, corresponds to a change of 100 on the Centigrade scale, making each Fahrenheit degree equal to 5/9 of a Centigrade degree. The following formula may be used to convert from one scale to another:

$$C = 5/9\ (F-32)$$

$$F = 9/5\ (C+32)$$

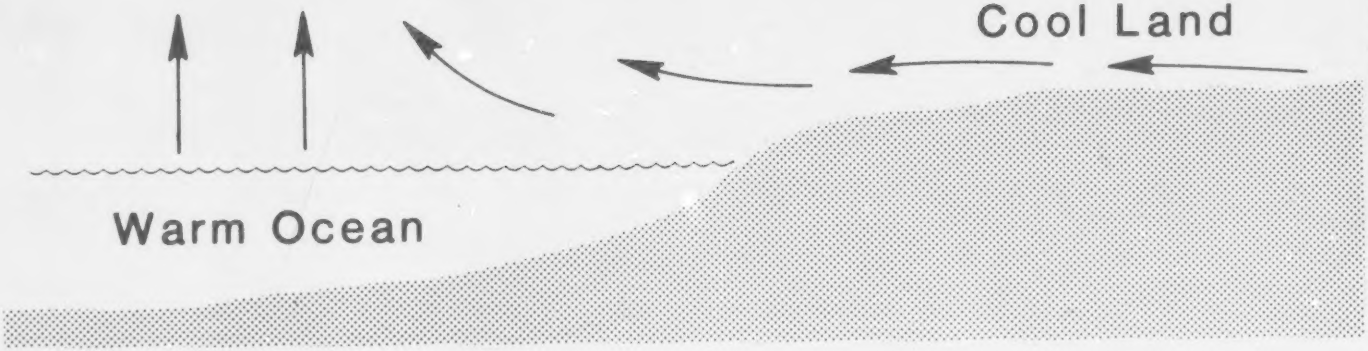


Figure 3-5. Warm Air Masses Rise. Cold Air Masses Fall and Flow Toward the Warm Air

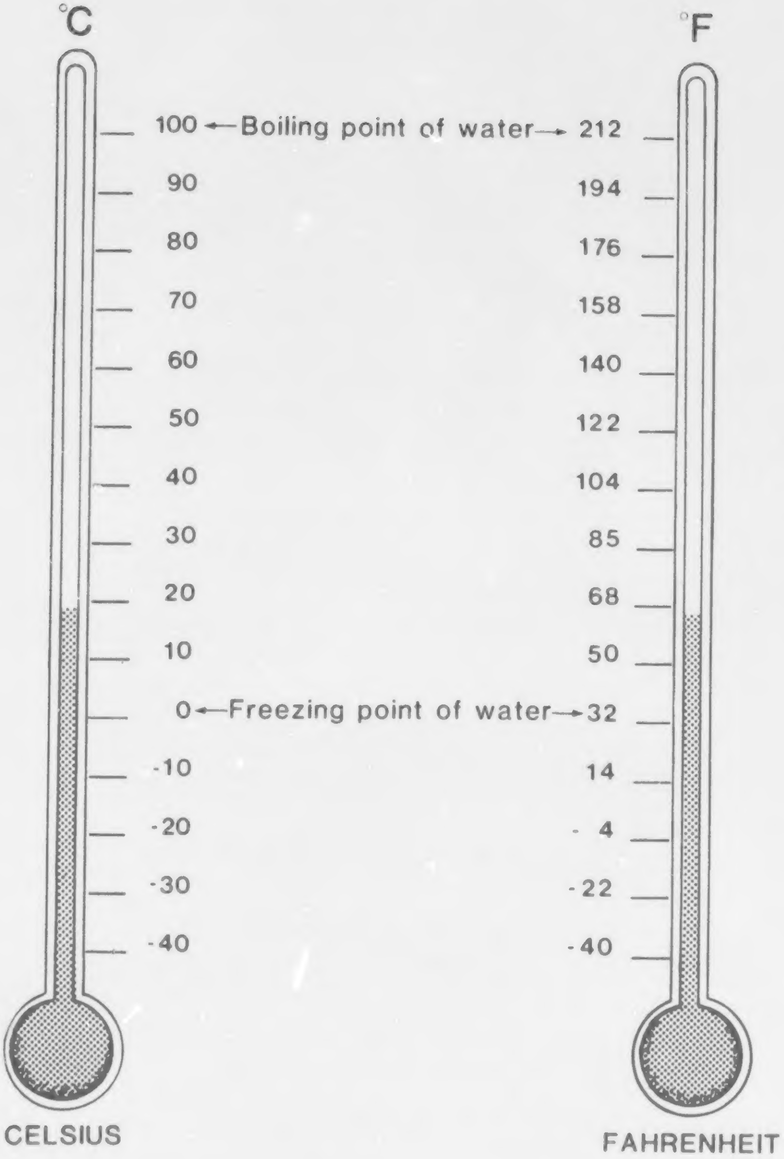


Figure 3-6. Celsius and Fahrenheit Scales

WATER IN THE ATMOSPHERE

Earlier we said that weather was caused by water vapor in the atmosphere being affected by heat. There is more water on the earth than any other substance. Almost 71 percent of the earth is covered with water and some of the seas are 30,000 feet deep. Only a tiny percent of this water goes into the air but this percent is the most important water in the world. This water vapor exists in the atmosphere for many miles and acts as a blanket for the earth holding the warmth gained from the sun. As liquid droplets, it turns into our clouds and fog that make up much of our weather. As rain and snow coming back to earth, it brings us the precious water we need to survive.

Most of the water vapor gets into the atmosphere by evaporation from the main water bodies of the earth. If you've seen a pan of water heated on a stove you've seen an actual experiment in evaporation.

Water also gets into the air by transpiration. An amazing amount of water transpires (evaporates) from the leaves of green plants. A single apple tree may move 1,800 gallons of water into the air in a six month growing season. As moist air rises, it slowly cools. Finally it cools so much that its relative humidity reaches 100 percent. Clouds form, and under certain conditions rain or snow falls. This eternal process of evaporation, condensation, and precipitation is called the hydrological cycle (figure 3-7).

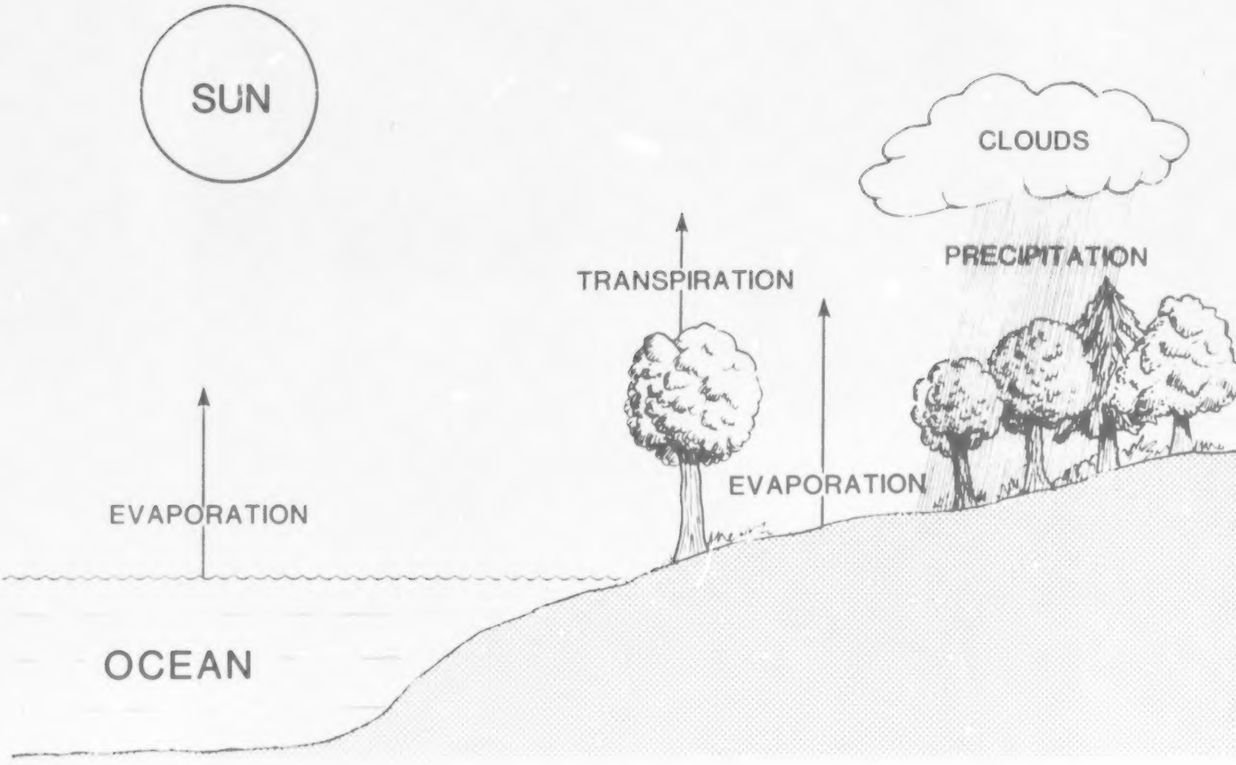


Figure 3-7. The Hydrological Cycle

STUDY QUESTIONS:

1. Air pressure is:

   a. air's hotness.
   b. air's wetness.
   c. air's weight.

2. Normal air pressure is approximately:

   a. 10 lbs per sq. inch.
   b. 15 lbs per sq. inch.
   c. 15 ozs per sq. inch.
   d. 10 ozs per sq. inch.

3. In a mercurial barometer it is important that there is a vacuum above the mercury column so that:

   a. only heat can cause the mercury to rise.
   b. nothing interferes with the up and down motion of the mercury.
   c. there is no downward pressure on the column.

4. When the mercury in the tube of a mercurial barometer begins to fall we can guess that the air pressure is:

   a. increasing.
   b. decreasing.
   c. remaining constant.

5. The most important influence in weather is ___________.

6. Weather is caused by ___________ ___________ in the atmosphere being affected by heat.

7. Water vapor serves two important uses. What are they?

   a. ___________________________
   b. ___________________________

8. The amount of water vapor in the air is called "humidity." The "relative humidity" is the amount of vapor the air is holding expressed as a percentage of the amount the air could hold at that particular temperature. Look at the chart below and answer the following questions.

   a. When air with a given amount of water vapor cools, its relative humidity ____________.

   b. 86°F is saturated when it holds _________ grams of water vapor per cubic meter.

   c. When does water vapor reach its dew point? ______________________

   d. What is the difference of grams per cubic meter between saturated air at 68°F and 86°F? ____________________

   e. What is the relative humidity of air when the temperature is 61°F and it is holding 7.27 grams of water per cubic meter? __________

TEMP.	RELATIVE HUMIDITY					
86°F	16%	24%	31%	45%	57%	100%
68°F	28%	42%	54%	79%	100%	
61°F	36%	53%	69%	100%		
50°F	52%	77%	100%			
43°F	67%	100%				
32°F	100%					
	4.85	7.27	9.41	13.65	17.31	30.4
	Grams of water vapor per cubic meter					

9. The temperature to which air must be cooled for condensation to occur is called:

   a. the dew point.
   b. the relative humidity.
   c. 0°C.

10. When water vapor is added to air:

   a. the air becomes less dense.
   b. the air becomes denser.
   c. the temperature rises.
   d. the air cools.

11. Air masses above different locations on the earth have different temperatures because:

   a. the sun strikes the earth at an angle.
   b. the earth rotates on its axis.
   c. heat is lost and absorbed at different rates.

12. Warm air masses (rise, fall). Cold air masses (fall, rise) and flow toward the warm air.

13. The degree of hotness or coldness of the air is measured by:

   a. barometer.
   b. barograph.
   c. thermometer.

14. Name the 2 different measurement scales thermometers use:

   a. ________________

   b. ________________

15. What formula is used to convert from one scale to another? ________________

VOCABULARY SKILLS:

Define the following words according to the definition given in the text.

1. One atmosphere
2. Millibar
3. Bar
4. Mercurial barometer
5. Aneroid barometer
6. Barograph
7. Radiant energy
8. Celsius scale
9. Fahrenheit scale
10. Dew point
11. Hydrological cycle
12. Transpiration

Each of the words below is hidden in the puzzle. Find and circle them. Words may be backward, forward, horizontal, or diagonal.

VOCABULARY WORD SEARCH

O	B	D	F	H	M	I	L	L	I	B	A	R	O	P	Q	R	S
C	N	E	G	I	J	Z	Y	X	W	V	T	U	A	C	F	G	H
X	W	E	Y	U	K	L	M	N	B	A	R	O	M	E	T	E	R
Y	Z	B	A	R	T	S	T	R	Q	P	E	D	B	I	K	J	E
B	U	O	I	T	E	A	R	A	C	Y	J	O	N	M	L	F	Z
C	D	A	F	C	M	N	A	N	H	P	A	R	G	O	R	A	B
O	N	N	C	L	A	O	N	O	A	N	C	L	A	Y	M	H	I
D	C	E	L	S	I	U	S	S	C	A	L	E	H	I	K	R	K
I	V	R	A	D	Y	I	P	P	K	K	I	M	O	L	L	E	E
H	A	O	P	P	Y	D	I	V	H	D	D	A	V	I	D	N	W
F	O	I	R	C	H	S	R	A	S	E	M	A	I	L	L	H	I
T	C	D	U	R	T	I	A	S	C	X	R	E	L	A	Y	E	T
T	N	E	R	B	I	K	T	D	E	W	K	E	I	M	N	I	O
K	A	T	H	Y	J	O	I	A	N	P	H	O	M	E	I	T	S
I	S	I	T	R	A	E	O	H	E	O	H	T	E	R	E	H	W
L	Y	O	U	V	T	E	N	O	O	I	D	A	D	M	O	M	I
O	G	R	A	D	I	A	N	T	E	N	E	R	G	Y	Y	R	A
L	N	G	I	Y	X	Z	Y	B	E	T	H	Z	Y	T	E	M	A

ONE ATMOSPHERE
MILLIBAR
BAR
BAROMETER
DEW
POINT

ANEROID
BAROGRAPH
RADIANT ENERGY
CELSIUS SCALE
FAHRENHEIT
TRANSPIRATION

BRAIN TEASERS FOR CLASS DISCUSSION:

1. Find out if your body can measure temperature.

   Use three pyrex bowls. Fill one with hot water, the second with room temperature water, and the third with ice water. While one student places the fingers of his right hand in the hot water (cautiously), the second student should do the same with ice water. The fingers should be kept in the bowls for about one minute. At the end of the minute, both students should move their right hand fingers into the third bowl (room temperature water). Each student should describe the water in the room temperature bowl. How does it feel? What is the basis for each student's description? How could you get a more accurate description of the temperature of the water?

2. Determine the effects of pressure on air movement.

   Inflate a balloon about half full of air. Hold the opening tightly closed with your hand. Where is the air pressure greater, inside or outside the balloon? Hold the balloon but release the opening. Which direction does the air flow, from balloon to the room or from room to the balloon? Does air flow from a region of higher pressure to a region of lower pressure or from a region of lower pressure to one where the pressure is higher?

3. Observe how rotation affects air pressure.

   Fill a gallon jug with water. Turn the jug upside down and watch the water flow from the jug (into a sink, of course). Also note the way air enters the container to replace the water that leaves the bottle.

   Refill the container, and this time quickly move the jug in a circular path immediately after the jug is inverted. Observe the air entering and the water leaving the jug using this method.

   Which method was most effective in getting air into the bottle? That is the same way large quantities of unstable air move aloft quickly in a violent storm like a tornado.

CLOUDS

** The continuous moving and turning of air partly explains the existence of the different kinds of clouds. **

> "I am the daughter of Earth and Water,
> and the nursling of the Sky;
> I pass through the pores of the Ocean
> and Shores;
> I change, but I cannot die."

The English poet, Shelley, used these lines to describe the seemingly magical formation of clouds. Clouds are everywhere. Seldom is the sky without them. Since early times, farmers, fishermen, and sailors have used clouds to predict weather.

In the preceding text we have discussed water vapor in the air and called it humidity. We have defined relative humidity as a percentage of the amount of vapor the air can hold at a given temperature. Now, we shall discuss the formation of water vapor into clouds, classify them by name and describe what kind of weather they may predict.

As you know the air is continually moving and turning. This movement partly explains the different kinds of clouds we see. It also explains why all clouds do not give us immediate rain. Basically, the water droplets can take three paths after they have formed. These three depend on the temperature of the air and its movement (wind).

1. Some droplets may bump into others and join with them until they get so big and heavy that they fall to earth as rain, snow or sleet.

or

2. The droplets can reevaporate, with the vapor carried higher into the atmosphere.

or

3. The droplets can rise and freeze into ice crystals and form high altitude clouds.

KINDS OF CLOUDS

In 1803 an Englishman named Luke Howard thought of a grouping system for clouds. Howard's method is the basis of our modern grouping system. Howard used Latin words to describe how the clouds looked to him.

He put clouds into four basic groups.

1. Stratus. These clouds looked like they were arranged in sheets or layers. (Latin for "layer" is stratur.)

2. Cumulus. These clouds looked like they were huge piles or heaps of cotton. (Latin for "pile" is cumulus.)

3. Cirrus. These clouds looked like thin feathers or hair. (Latin for "hair" is cirrus.)

4. Nimbus. This fourth division shows if a cloud has a form of water falling from it. The word "nimbus" is joined with other cloud names to indicate the presence of water. (Latin for "rain cloud" is nimbus.) So by combining "nimbus" with another cloud name, we are saying that the cloud is causing rain, snow, or sleet to fall. Therefore, a cumulo-nimbus cloud is a cumulus cloud that is causing rain.

These shapes of clouds occur at different altitudes. The height (altitude) of the cloud is a second way to talk about it. The altitudes are High, Middle, Low, and Towering (a very high cloud that has its base in the low altitude area and its top in the high area). Because it is so tall, it contains many different winds.

Following is a list of the cloud families and their members (figure 3-8). After each name is a short description of the cloud and the kind of weather it brings.

FAMILY I. High Clouds - 20,000 ft. and above

1. Cirrus: thin, feathery made of ice crystals. In scattered patches, shows cold and clear weather. In parallel lines, violent change in weather within 36 hours
2. Cirro-cumulus: thin, patchy wave-like patterns, shows rain or snow in 24 hours
3. Cirro-stratus: filmy cloud covering the sky, shows clear and cold weather.

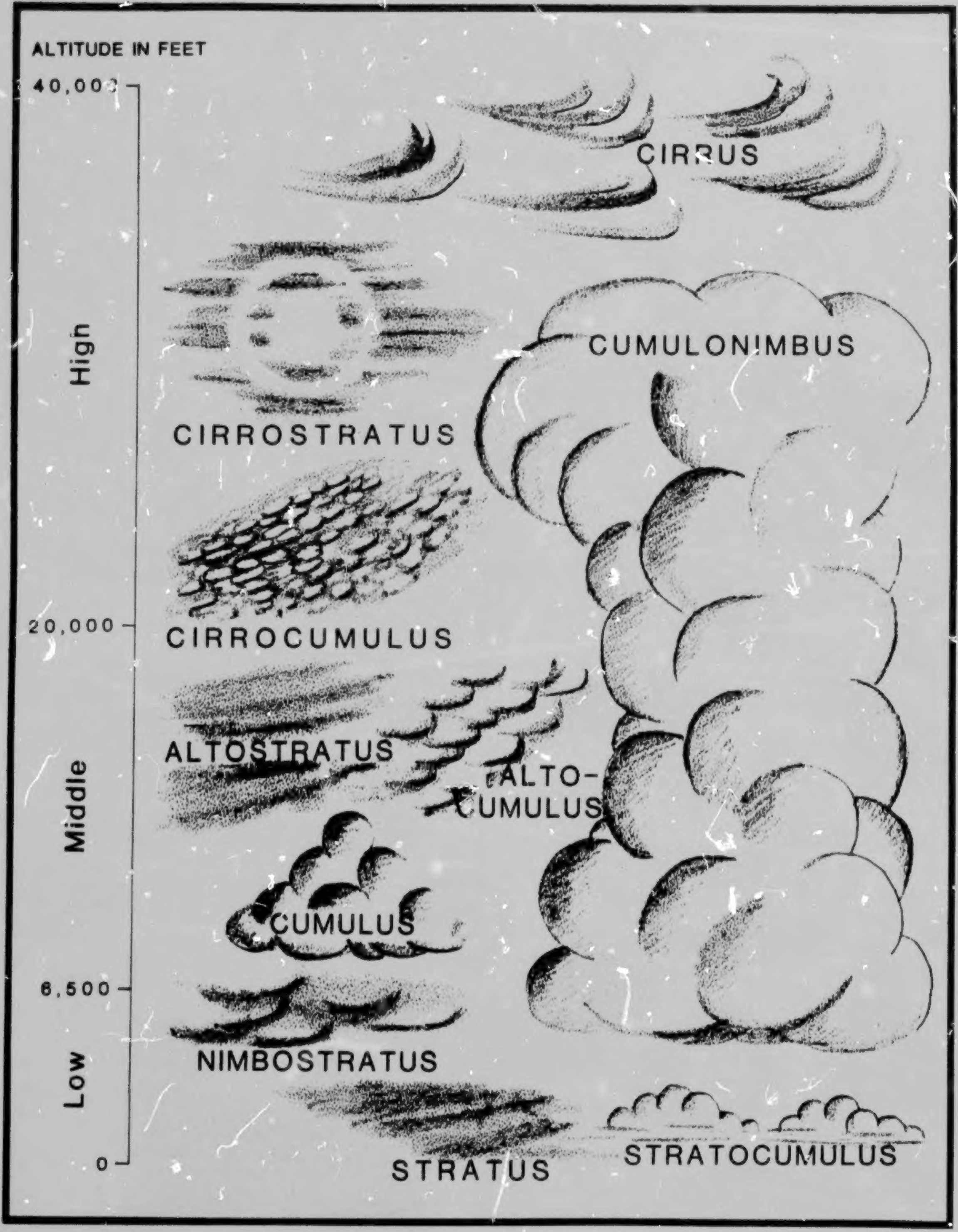


Figure 3-8. A Vertical Arrangement of Cloud Types

FAMILY II. Middle Clouds - 6,500 to 20,000 ft.

1. Alto-cumulus: gray or whitish layers like sheep's wool, shows rain within 24 hours
2. Alto-stratus: dense sheets of gray or blue, shows light rain in 24 hours.

FAMILY III. Low Clouds - surface to 6,500 ft.

1. Strato-cumulus: rounded puffy layers, shows no rain but brings bad weather
2. Stratus: gray layer, brings drizzle
3. Nimbo Stratus: dark, shapeless, blankets the skies, brings heavy rain or snow.

FAMILY IV. Towering - bases starting at about 1,600 ft. and tops as high as 40,000 ft.

1. Cumulus: dense, puffy, giant white cotton, brings good weather
2. Cumulo-Nimbus: dense, towering, dark, brings severe thunderstorms or tornadoes in summer.

Each of the above tells something about the atmosphere. Each is a clear billboard if you know how to read it. For example, cirro-cumulus and cirro-stratus (both high clouds) occur in the front of a storm center and show that it is coming. Nimbo-stratus (a low cloud) brings steady rain or snow. It brings bad visibility, low ceilings, and often icing conditions. Cumulo-nimbus (one of the towering clouds) means violent weather: lightning, thunder, hail, downpouring rain, and very high winds (figure 3-9). The rain storm that comes with cumulo-nimbus may create great destruction.

FORMS OF WATER (PRECIPITATION)

RAIN

The water droplets in a cloud are tiny, so tiny that you could not see them without a microscope. They are 1/2,500 of an inch in diameter. They are too light to fall to earth. But these droplets bump into one another and join. This is called coalescence. When the drops get to

COMING SOON....
LIGHTNING!
THUNDER!
RAIN!
A CUMULONIMBUS PRESENTATION

Figure 3-9. Cumulonimbus Presentation (Storm Covering)

be at least 1/125 of an inch they are heavy enough to fall. The most common coalescence happens when ice crystals and water droplets form near one another in a high cloud. The droplets evaporate back into water vapor. The water vapor bumps into the ice crystals and condenses again but this time as snow or ice pellets. These are heavy enough to fall towards the earth. As they fall through the warmer air at lower altitudes, they melt into large water drops. These reach the earth as rain.

SLEET, HAIL, SNOW, FOG

Sleet is really half-frozen rain. It forms when drops fall through a layer of freezing air. The rain will not freeze unless it comes into contact with some hygroscopic nuclei, dust. Only then does the rain partially freeze. When it hits the ground it freezes. This happens in winter. It is dangerous; its weight has been known to crush cars and destroy trees.

Hail usually occurs in the summertime and is commonly connected with thunderstorms. This is because hail can only form in very rough air. A piece of hail is really a series of ice circles, one inside the other. One circle is clear hard ice and the next is soft whitish ice and so on. Hail pellets are formed in the higher parts of cumulo-nimbus clouds. As the frozen drop falls through the cloud, it collects a coating of water. But because of the strong winds within this giant cloud the pellet is tossed back upward and the water freezes into another ice layer. This goes on with the pellet falling and being tossed back up until it is heavy enough to fall down through the lifting power of the wind. Then it falls to earth. Most of the time it reaches the earth as ice. Hailstones of four inches in diameter and weighing one pound have often been recorded by meteorologists. Hail can be terribly destructive, especially since it commonly comes in summer before the crops have been harvested.

Snow results from water vapor condensing at a temperature below 32°F. Tiny ice particles form in this way. They join and have enough weight to fall from a cloud. About 12 inches of snow make the same amount of water as one inch of rain. But the wetter the snow, the more water it brings. This probably explains why people talk about fine powdery or wet snow.

Fog is simply a big cloud lying close to the ground. Fog forms when a mass of cool air moves in and mixes with warm air that has a high relative humidity. When the temperature of the damp air drops to its dew point, fog is formed. Of the millions of water droplets that make up a fog, each has a speck of dust or smoke as its center.

So to have fog, three conditions must be present: (1) moist air, (2) a breeze, and (3) a combination of warm and cool temperatures. Fog does not give much water to the earth's surface; but it does give us a big problem: it hinders visibility both at sea, on land, and in the air. For sailors, fog has always been a dangerous enemy. It has made navigation dangerous and sometimes impossible.

Fog occurs commonly at sea. When a mass of warm air passes first over warm water and then moves over colder water, fog is likely to form. This process is called advection. Advection here means moving forward. The heaviest fogs occur when two large bodies of water that are next to each other have very different temperatures.

But no matter where fog occurs, the most important condition for making it is the difference between the air's temperature and its dew point and how much cooling is necessary to reach the dew point. An example would be a mass of air that moves onto the coast of England during the winter. The temperature might be 38°F with a dew point of 36°F. Therefore, only 2° of cooling will be needed for fog to form and cover the coast.

STUDY QUESTIONS:

1. A cloud is defined as:

    a. a mass of water vapor.
    b. tiny particles of dirt.
    c. both a and b.

2. a. How is fog formed and how is it different from a cloud? ______________
    ____

    b. What three conditions must be present?

    (1) ______________
    (2) ______________
    (3) ______________

3. As water droplets ride air currents, three things can happen:

    a. evaporate, freeze, fall back to earth.
    b. reevaporate, form ice crystals, condense.
    c. reevaporate, form ice crystals, fall back to earth.

4. Name the four basic groups of clouds:

    a. ______________
    b. ______________
    c. ______________
    d. ______________

5. Appearance and altitude together combine for still another grouping of clouds. Name the four major family groups and list the clouds found in each.

    Family I ________________
    a. ________________
    b. ________________
    c. ________________

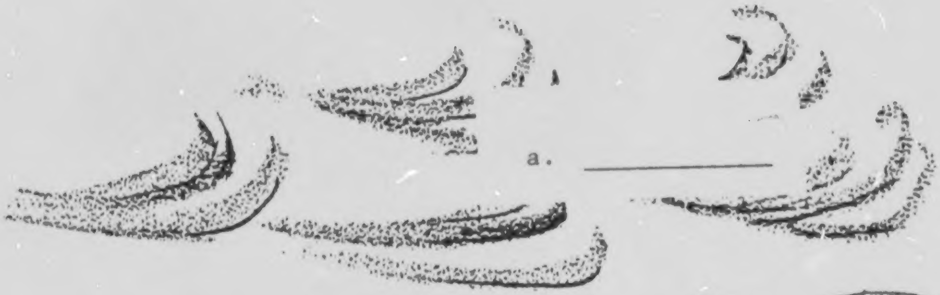
    Family II ________________
    a. ________________
    b. ________________

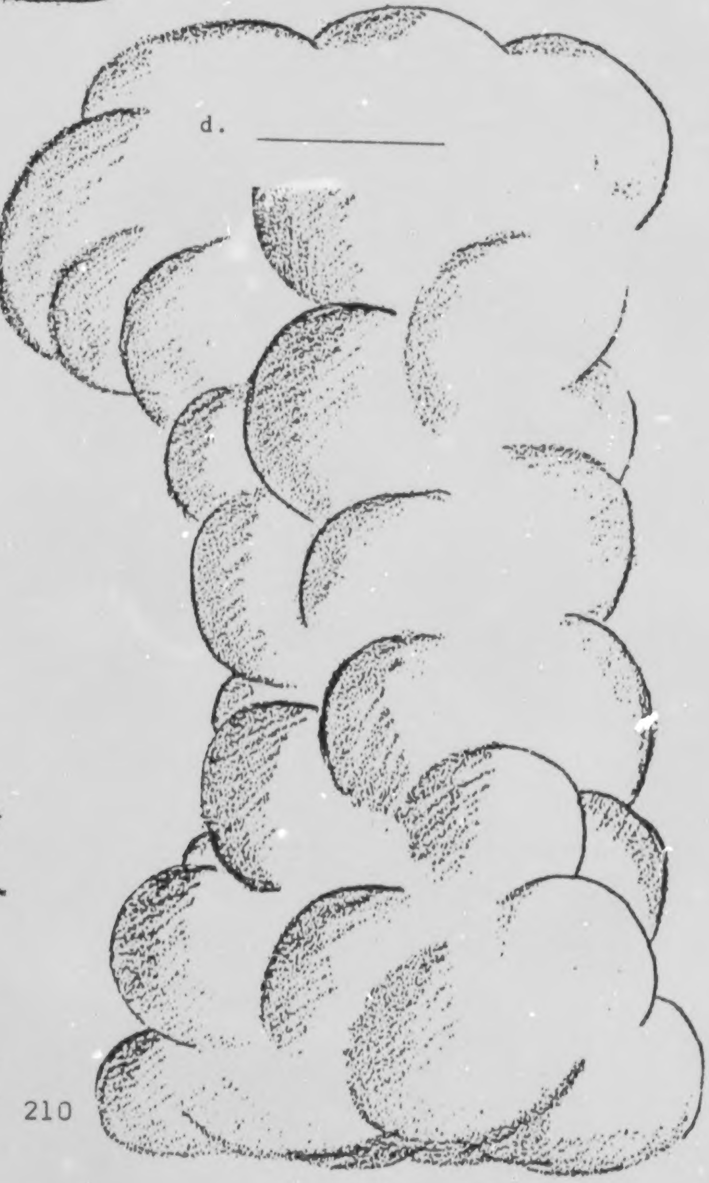
    Family III ________________
    a. ________________
    b. ________________
    c. ________________

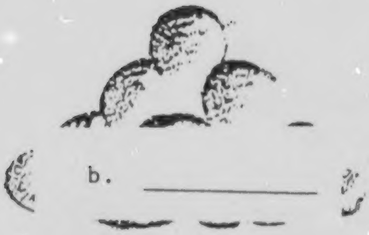
    Family IV ________________
    a. ________________
    b. ________________

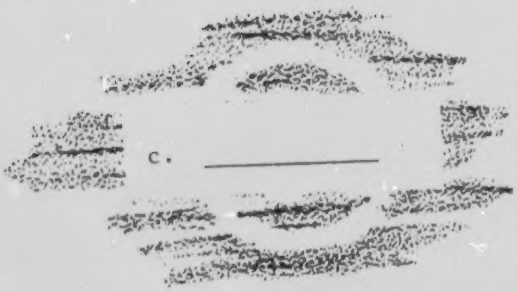
6. Look at the pictures of clouds below and label them from the following list.

Cirrostratus
Cumulus
Cirrus
Cumulo-Nimbus









7. Look at the conditions below and identify what type of precipitation might occur. The correct choices are listed below:

a. Cool air moves in and mixes with warm air having a high relative humidity. The temperature falls below dew point and a gentle breeze is blowing ____________________.

b. In the wintertime, the upper air is 0°F, water vapor condenses and forms ice crystals and it floats to the ground ______________.

c. Water vapor has condensed on objects that have cooled below the condensation point of the air around them. Relative humidity has reached 100% ____________.

d. Water vapor changes directly to ice crystals on contact with an object ______________.

e. Moist air is cooled to the point where the moisture condenses into heavy drops. The droplets grow to 1/125 of an inch in diameter. The temperature is 60°F ________________.

f. The temperature is 98°F. Cumulo-nimbus clouds are present. The wind is very strong within the cloud ______________.

(1) snow
(2) frost
(3) fog
(4) hail
(5) rain
(6) dew

FIND THE MYSTERY WORD:

8. a. ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ What it is called when rain droplets bump into each other.
1 2 3 4 5 6 7 8 9 10 11

b. ___ ___ ___ ___ ___ ___ ___ ___ ___ What it is called when a mass of warm air passes first over warm water and then over colder water.
12 13 14 15 16 17 18 19 20

c. ___ ___ ___ A big cloud lying close to the ground.
21 22 23

d. ___ ___ ___ ___ ___ ___ ___ ___ Height
24 25 26 27 28 29 30 31

e. ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___
32 33 34 35 36 37 38 39 40 41 42

___ ___ ___ ___ ___ ___ Dust
43 44 45 46 47 48

Fill in the blanks above. Then find the number of the letters needed to fill in the word below. The above words are all related and should give you a clue as to what the mystery word should be.

MYSTERY
WORD:
___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___
40 35 31 1 18 40 18 26 12 26 18 22 9

VOCABULARY SKILLS:

Define the following words according to the definition given in the text.

1. Precipitation.
2. Hygroscopic nuclei.
3. Altitude.
4. Coalescence.
5. Advection.

BRAIN TEASER:

Study the clouds, wind direction, temperature, and air pressure on a given day and try to predict the weather on your observations.

WIND AND WEATHER

** Wind blows in different directions with different forces because of uneven atmospheric pressure, i.e., forces trying to push air from higher pressure to lower pressure.**

Air in motion is called wind. Although we are unable to see the wind we can see what the winds carry -- leaves, dust, etc.

This was a great mystery to ancient man because he thought there was nothing there. He did not realize that the wind was really a weighty substance in motion. He did not understand that rivers of air were really flowing across the sky in a different direction with different forces.

Winds are of fundamental importance in making our weather what it is. In the first place, the motion itself is a weather factor of importance -- a quiet winter's day may be pleasant and a windy day may be disagreeable. In the second place, the physical condition of the air is largely a function of its source and horizontal movement.

The wind blows in a different direction with different forces because of uneven atmospheric pressures. You already know that there are different temperatures all over the earth. One area heats quickly while another heats more slowly. With these different temperatures, the atmosphere also has different air pressures. These pressures try to balance themselves. If you fill a child's balloon with air and then release it you will see how different air pressures try to balance themselves. The air inside the balloon will rush out to meet the lower pressure air outside. As you already know, normal air pressure is approximately 15 lbs. per square inch. The air inside tries to reach this pressure. In a similar way, winds are caused by the forces trying to push air from higher pressure to lower pressure.

DIFFERENT WINDS

There are many kinds of winds. There are local winds and global winds. Local winds are mainly caused by convection (figure 3-10). Local winds blowing over the land or blowing over the sea are usually shallow and go short distances. They do not stretch around the earth. These local winds blow from a high-pressure area to a low-pressure area.

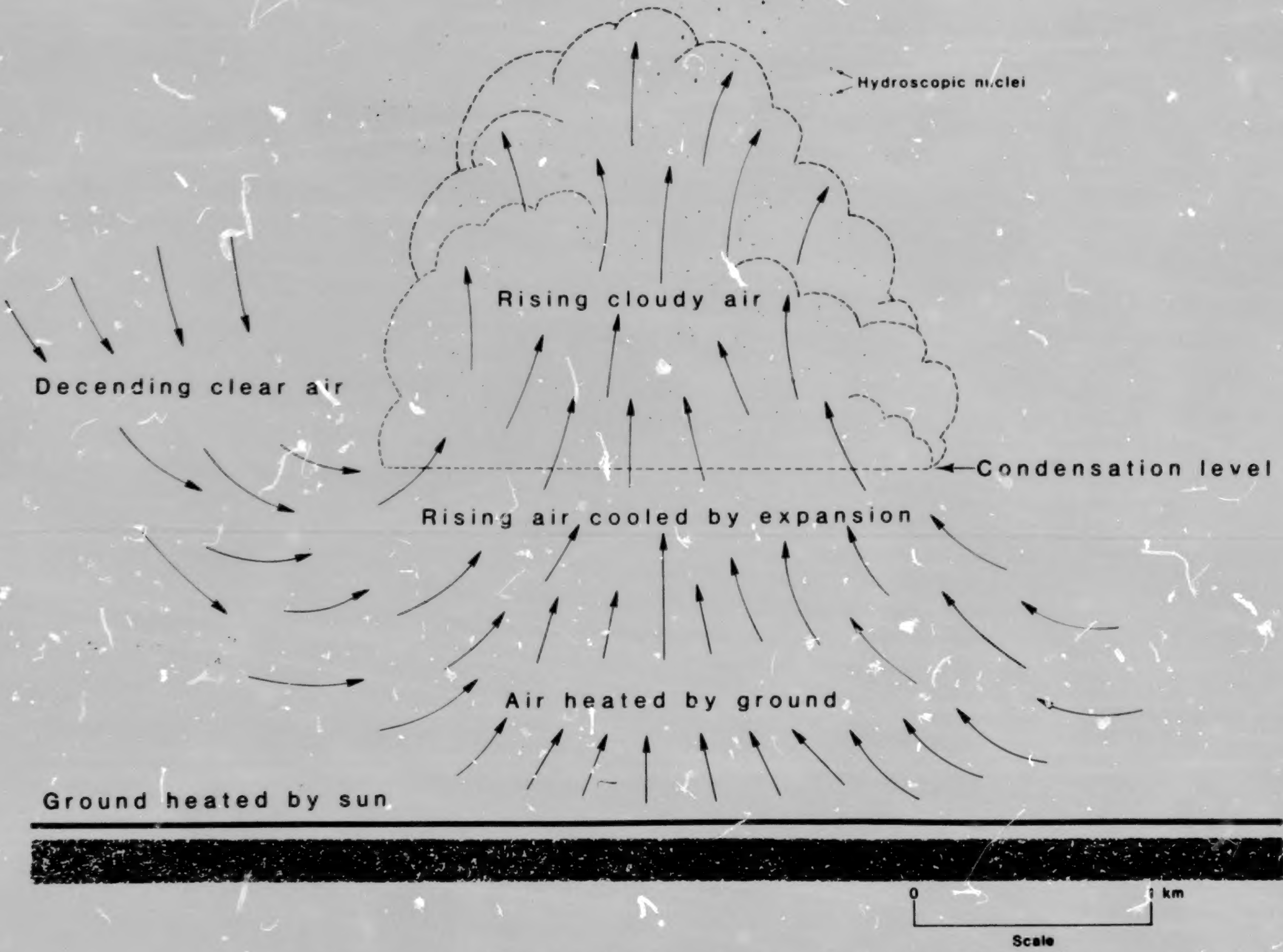


Figure 3-10. The Formation of a Cumulus Cloud by Convection

The sun heats up the land during the day. And the land heats up the air. As you know the air then rises. When it rises, it leaves an empty place where the cool, heavier air rushes in to fill the empty place. The air rushes from high pressure to low pressure. At night, the reverse occurs and so the winds reverse their direction. Along the coastlines of the tropics this process is as dependable as anything known in nature. It is true that the hotter the climate, the stronger and farther the breezes blow. You can compare this process to water flowing down a hill. The greater the differences in pressure (temperatures), the steeper the hill. The steeper the hill the stronger the winds will blow.

The larger, more far-reaching winds really act like the smaller, local ones. But they act on a larger scale: they travel much farther. In fact, they travel over the entire earth. And so they are affected by the main influences that govern the earth.

There are great bands of wind that blow all the way around the Northern and Southern hemispheres of the earth.

Like smaller winds our greatest winds are powered by a difference in temperature. But in the case of the global winds, the temperature difference is between the freezing poles and the hot equator.

Basically, the air at the equator, the Doldrums zone, heats up higher than anywhere else on earth. As this air heats it rises high into the atmosphere. Much of the air rises, expands, condenses, cools, and creates huge thunder clouds. Here tropical storms occur often. This kind of weather occurs for about 1,000 miles north and south of the equator.

Some of this equatorial air rises very high above the equator and begins to flow toward both poles. By the time this air reaches about 1/3 of the way to the North Pole, it has cooled and begins to sink down toward the earth's surface. This sinking air forms an area of higher pressure around the earth at about 30° latitude. In the northern half of the earth it occurs at 30°N latitude; in the southern at 30°S latitude. These are sometimes called the horse latitudes probably because during the early days, sailing ships often became dangerously becalmed in waters on this part of the earth. The weather was so calm, the sailors tossed their heaviest cargoes over the side just so the ships could be lighter and take advantage of a tiny breeze. The heaviest cargo was their horses. So these wind belts are known as the "horse" latitudes.

At the same time as the equatorial air is making its trip, the cold polar air masses are beginning their trips.

It seems as if the air masses are moving in two simple, straight rivers. But the process is more complicated. The rivers are bent as they flow. The spinning of the earth on its axis from west to east stops the air from traveling directly north or south. The rivers of wind are turned and bent into a complicated system of wind currents (figure 3-11).

This is known as the Coriolis Effect. In the Northern hemisphere all air headed south is twisted and blows toward the southwest and in the Southern hemisphere, the air headed north is twisted and blows northeast.

Meteorologists refer to winds not by the direction toward which they are blowing but by the direction from which they come. So, a wind blowing toward the southwest is called a northeast wind.

The air headed north is twisted to the northeast and so is called by meteorologists a southwest wind.

The winds that blow from the horse latitudes south toward the equator are the trade winds. These are the steadiest winds known to man. They are called the "trade" winds because the earliest traders relied on them for constant, dependable weather.

The air flowing northward from the horse latitudes is also twisted by the earth's spin and flows to the northeast. Meteorologists call this wind a southwesterly (or the Westerlies), again because of the direction it is coming from. These Southwesterlies are called "the Prevailing Westerlies" and blow in a giant belt around the earth from the latitude of northern Florida to the latitude of Newfoundland. In other words, the Prevailing Westerlies in the Northern hemisphere occur from about 30°N to 55°N. Most of the United States is included in this area.

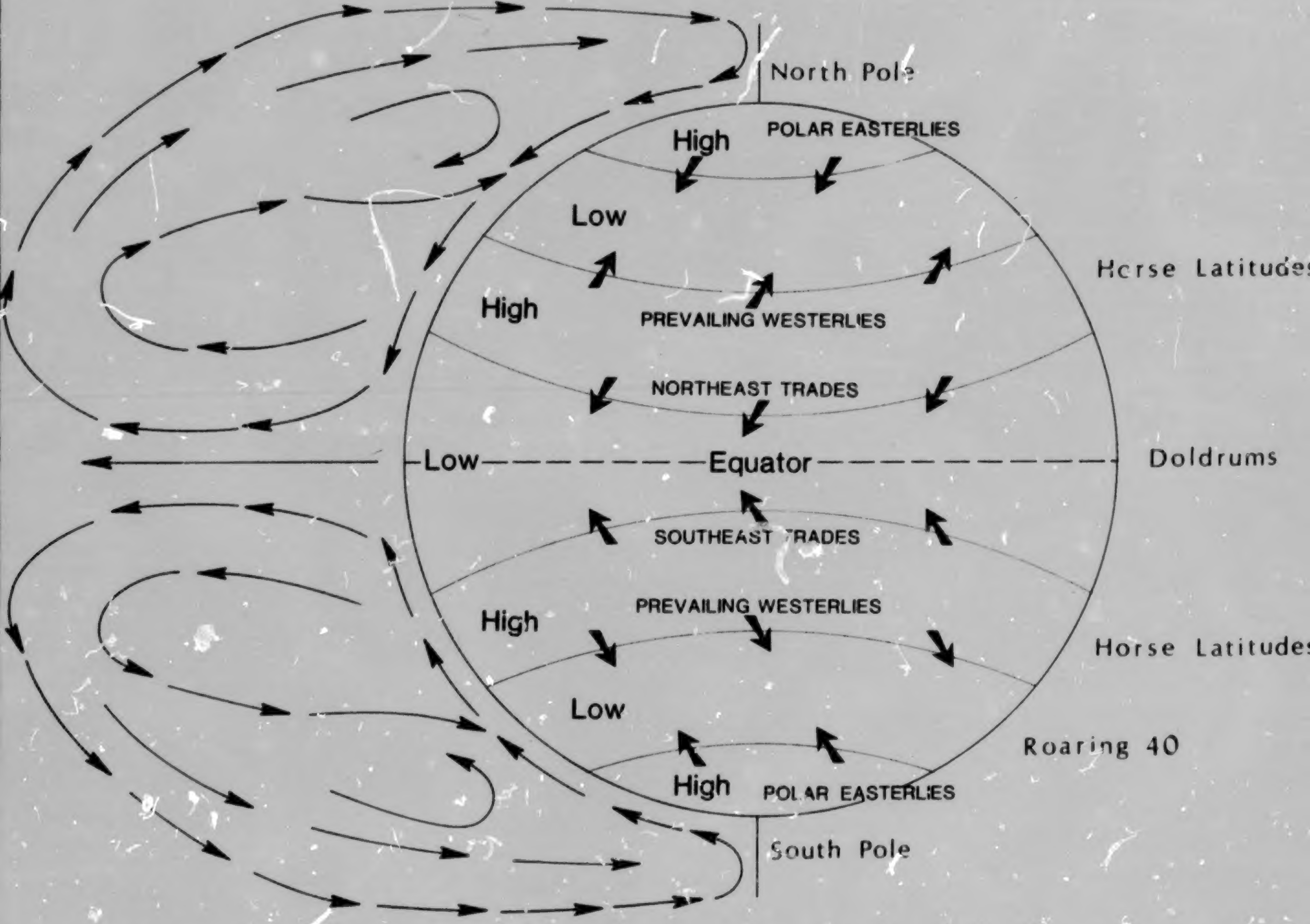


Figure 3-11. Simplified General Circulation of Air Over the Earth

Most of the people in the world live in 30° to 50° latitudes which are generally known as the Temperate Zone. Both cold and warm air alternate in the Temperate Zone. As a result it is characterized by sudden changes in the weather.

There is another great wind belt encircling the earth. There are freezing cold winds sweeping over northern Canada and Siberia. These winds come partly from the North Pole but also from that first mass of air we talked about that started at the equator. You remember that part of that air rose into altitudes high above the earth. Some of it sank down to form the Trade Winds. Some of it sank down to form the Westerlies. And some of it went on to the top of the earth where it sank. Here it was cold and heavy and formed an area of high pressure. These winds bulge out to have a northeasterly direction in the Northern hemisphere and a southeasterly direction in the Southern hemisphere. These winds are called the Polar Easterlies.

In summary, there are four major classifications of prevailing winds:

1. The Doldrums, the equatorial belt of light and variable converging winds
2. Trade winds, bands of easterly winds
3. Prevailing Westerlies, which provide most of the air flow over the U.S.
4. Polar Easterlies, a zone of poorly developed surface wind.

Together they form the general circulation of the earth's atmosphere.

However, there is also a pattern of smaller wind systems within the larger pattern. These smaller winds occur simply because the earth itself is not the same shape over its entire surface. Oceans and land area do not heat up equally during the year.

Oceans heat up more slowly, but also cool more slowly than the land. As a result, in winter the water cools more slowly than the land masses. Different areas of pressure are the result. And so we have smaller circles of air that can be called "secondary" circulation systems. In actuality, we have small parts of the primary wind circulation, changed and moved into smaller circles of air.

21-

Looking down at the earth from a satellite we could see the giant wind belts. But we could also see the other circles of air spinning around. Some are spinning clockwise (highs) and others are spinning counter-clockwise (lows). Some are over the oceans; some over the continents. They change a bit as the seasons change but the same general areas seem recognizable. In fact, they seem very much alike throughout the year, and remain in the same place. They are so much the same, they can be named. Their names come from the general regions in which they are found. Together, they are called centers of action. You can easily see why. Some are high-pressure and some are low. They are centers of action because as high and low-pressure areas, they act as great wind machines. Often these wind machines decide the weather for an entire nation or even an entire continent. They bring cold and warm winds over far distances but not as far as the primary, worldwide winds.

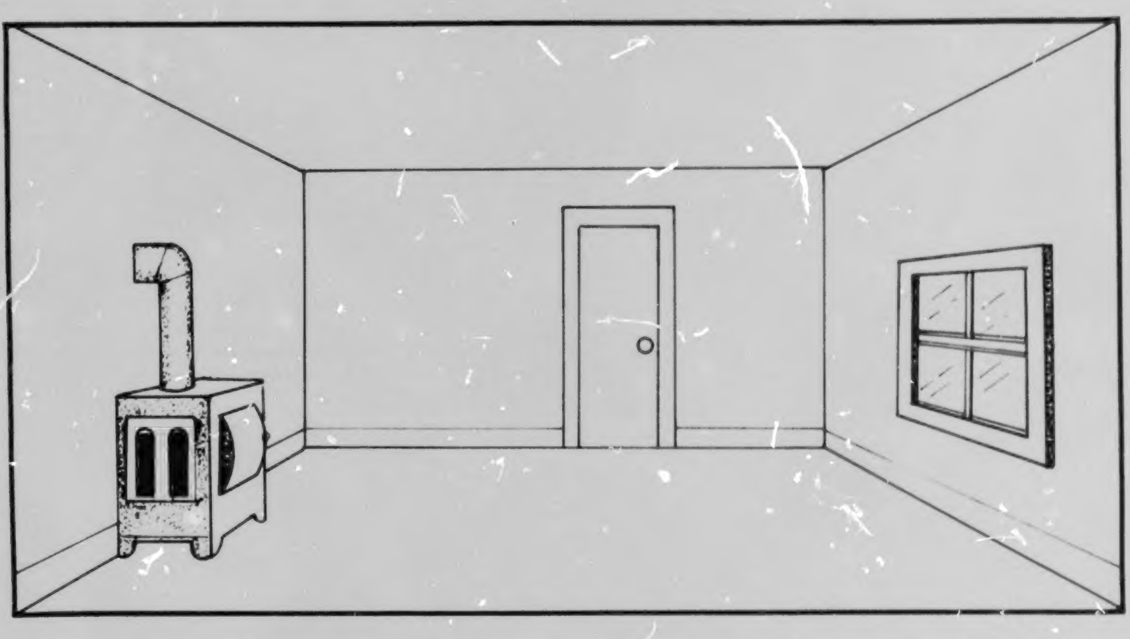
HIGHS (ANTICYCLONES)

An easy way to understand these high and low-pressure areas is to first picture the earth's atmosphere as a closed-up room (figure 3-12). The windows are all sealed and the blinds are tightly closed. Even the crack under the door is stuffed with cotton. In this room, there is no air circulating. The dust in the air settles. In this room the air pressure is the same everywhere. There are no highs. There are no lows. There are no temperature differences. There are no humidity differences -- and, of course, there are no winds.

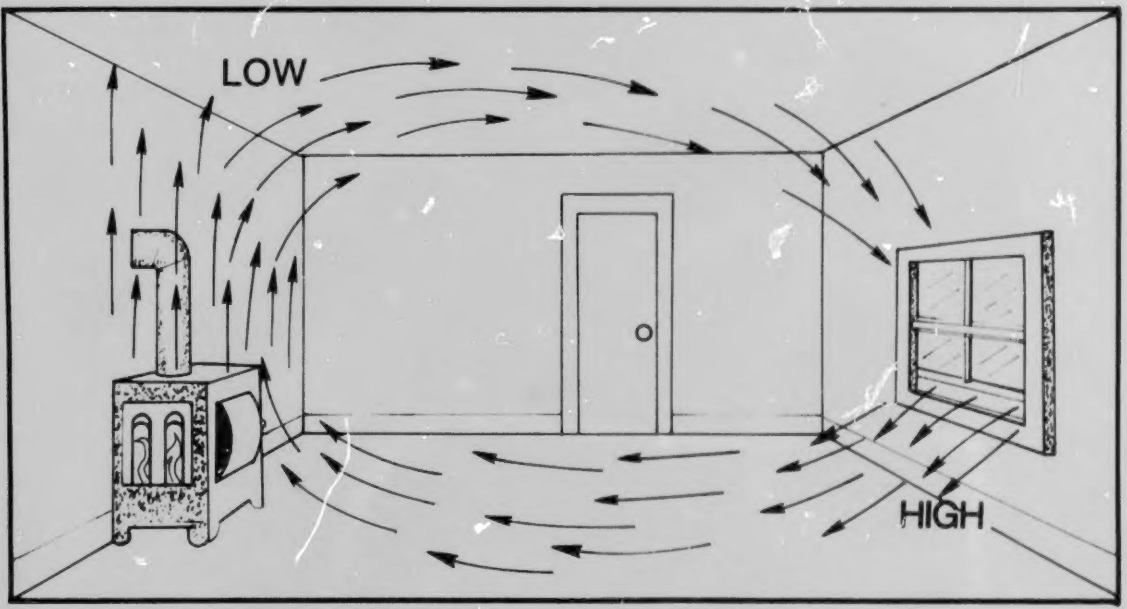
Now, pretend that on a winter night, you opened one window slightly. At the same time you lit the wood stove that stood about five feet across from the window. What do you think would happen to the air inside the room?

Above the stove, the air getting warmer and warmer would rise and expand. Within a short time all the air above the stove would be lighter than the general air in the room. The air above the stove, being lighter, would be exerting less pressure on the floor under it. This air is a miniature example of a low.

The air in the rest of the room, especially near the window, would be cooler and would be squeezed down by its own weight to the floor. It would be trying to seek a place to go. This is a miniature example of a high. The air in the high would naturally flow towards the less pressurized



① A closed up room. Stove is unlit and window is shut.



② Cold air flows in through open window. Air rises over hot stove.

Figure 3-12. Example of Air Pressure

low. Once it reached the low, it would get heated and rise. Of course, the areas of greatest pressure or lack of it (and also greater movement) would occur closest to the cold air coming in the window and the very hot air rising above the stove. Imagine these low and high areas in the atmosphere multiplied in area and volume by millions of cubic feet and you can see how lows and highs make a circulation system.

Local high-pressure areas will develop anywhere air cools, compresses and falls. When a high-pressure area forms, the air begins to flow outward to a local low-pressure system. In the Northern hemisphere this air spins clockwise.

Anyone who lives in the Eastern United States is really inside this giant spinning clock of air. The center of the clock is the Atlantic Ocean. The outer edges of the clock are winds that touch at least 12 separate nations. The winds in this high center blow from the northwest coast of Africa straight across the Atlantic Ocean to the east coast of the United States. Then they go back across the Atlantic to England, down the western coast of Africa. They have completed their circle and will start again. This center is known as the Bermuda High (figure 3-13). There are other major high-pressure areas, most of which exist close to the poles. There is a constant high over Greenland all the time because of its ice cap.

There are highs southwest of California and near the Azores in the Atlantic. And, there is one in freezing Siberia.

LOWS

There is only one stable low-pressure area on the earth. This, as you would expect, is in the Doldrums near the equator. There are, however, smaller lows found all over the earth. For example, moving low-pressure areas are frequently found just in front of the polar highs. These areas are formed by the interaction of the cold polar air to the north and the tropical air to the south. These areas are called migratory lows (figure 3-14).

MOUNTAIN WINDS AND VALLEY WINDS

As you've already seen, the different surfaces on the earth heat up at different rates. These differences on a gigantic scale effect the global wind systems and create smaller but still very sizable centers.

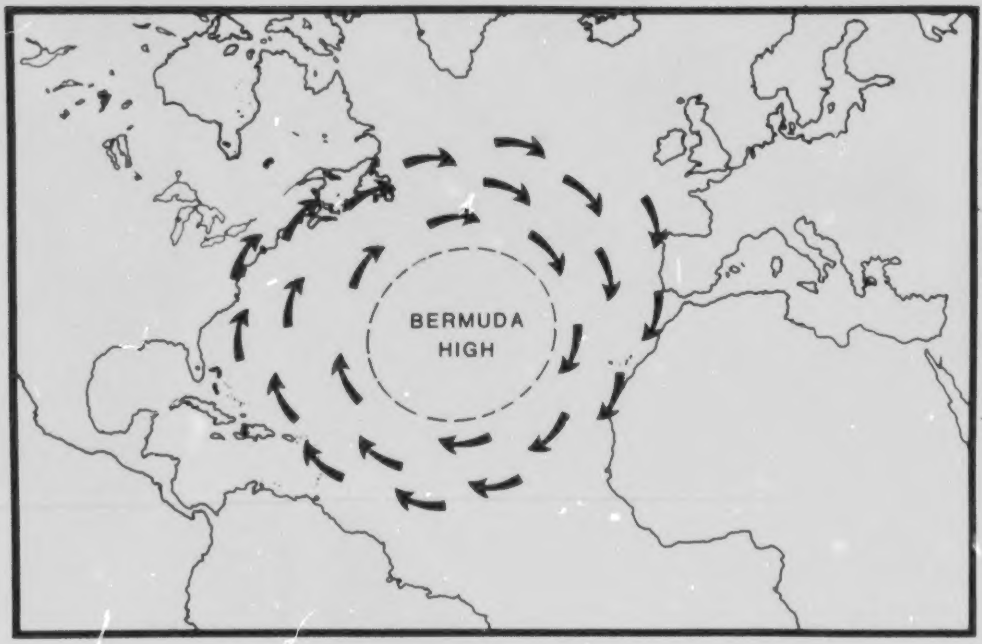


Figure 3-13. Bermuda High

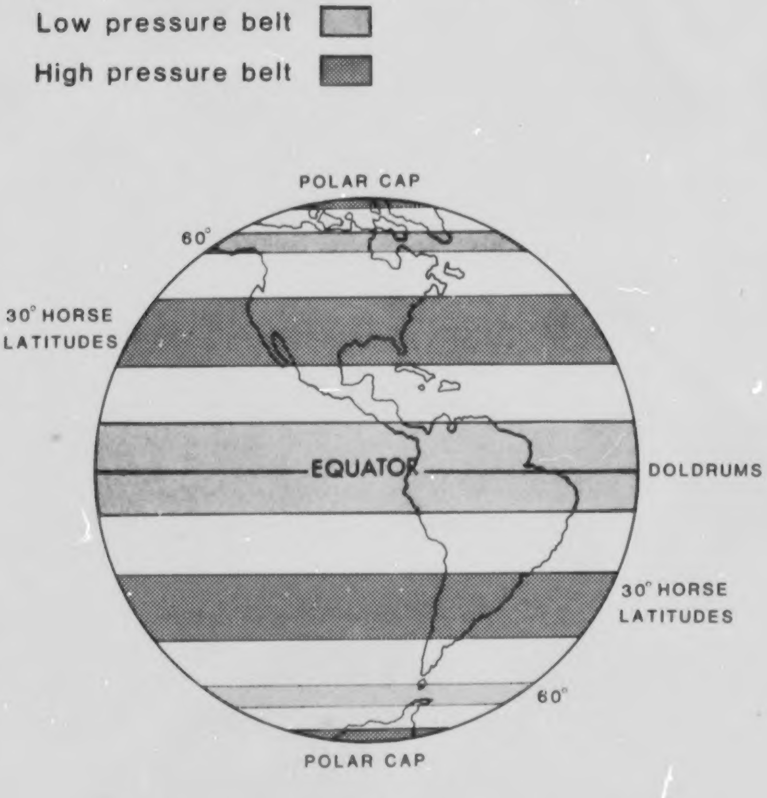


Figure 3-14. Global High and Low Pressure Belts

On an even smaller scale, the same process holds true. The heating and cooling process explains mountain and valley winds.

On a warm, sunny day, mountain slopes are much warmer than the air at the same levels. This heating causes the wind to blow upward from the lower valley.

The slopes get colder at night than the air around them. Then the wind flows downward into the valley. These winds can reach very high speeds.

MONSOONS

The monsoon is a very strong wind that comes regularly. In some areas, like Southeast Asia, the monsoon comes to the land as regularly as summer or winter. Again, the process that creates monsoons is a result of high and low-pressure areas. As the millions of miles that make up the continent of Asia begin to grow hot in the spring, the ground dries out and gets hotter. At the same time, the Indian Ocean is changing its temperature but more slowly than the land. And so the air over the ocean remains much cooler than that over the vast land mass. As the land continues heating, a low develops. The low over the land draws the cooler, moisture-filled air from over the ocean. As the air pushes over the giant continent, it begins to cool. It condenses, and rain begins to fall in huge quantities, wetting the lands and irrigating the crops that provide food for the millions of people in Asia. It is common for the southeast coast of Burma to have 200 inches of rain from mid-May to September. Without the monsoons millions of people would starve. In the winter the process reverses itself with the winds flowing off the Continent toward the ocean.

THE BEAUFORT WIND SCALE

Recall that the instrument used to measure wind direction and speed is called an anemometer. The simplest form of this instrument, you remember, is the weather vane.

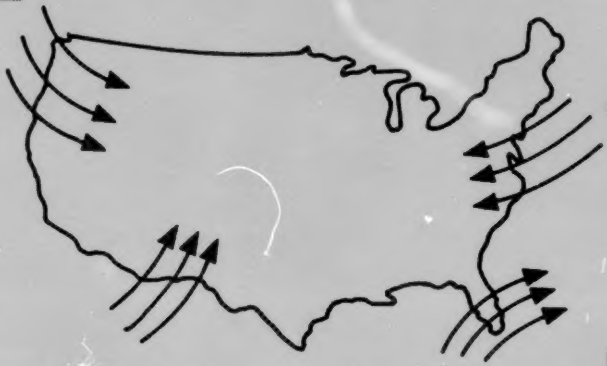
The Navy uses the anemometer all the time. Practically every commissioned vessel carries an anemometer. The wind speed is recorded in knots.

There is also a scale called the Beaufort Wind Scale. This was invented in 1805 by Admiral Sir Francis Beaufort of the British Royal Navy. After years of sailing, Admiral Beaufort drew up a scale of the winds according to how powerful they were. The scale runs from 1 to 12 with 1 representing the lightest winds and 12 representing hurricanes and typhoons. He also described what the sea acted like in such winds and even included the height of the waves.

STUDY QUESTIONS:

1. Study the chart below and label the winds by name.

d. _______________

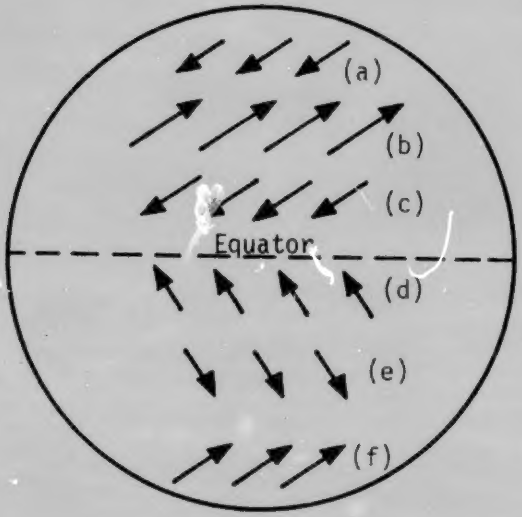


a. _______________

c. _______________

b. _______________

2. On the globe below, label the global winds.



a. _______________

b. _______________

c. _______________

d. _______________

e. _______________

f. _______________

3. Why do the winds not travel directly from north to south?

   a. earth's rotation around sun.
   b. earth's spinning from east to west on its axis.
   c. earth's spinning from west to east on its axis.

4. True or False:

   a. High pressure develops where air cools, compresses, and sinks; and flows toward low pressure. T F

   b. Low pressure is formed between two highs of different temperatures. T F

5. Secondary circulation systems of air are caused by:

   a. the shape of the earth's surface.
   b. heating and cooling of land and water.
   c. both a and b.

6. Air must always flow (outward, inward) from a high pressure area.

7. Complete the chart below with facts about highs and lows.

	Highs	Lows
Weather		
Air Circulation		
Winds		
Temperatures		

8. The belts of high pressure found at 30° north and south latitude are called:

   a. trade winds.
   b. Doldrums.
   c. horse latitudes.

9. The most steady wind belt in both speed and direction is the:

   a. trade winds.
   b. prevailing westerlies.
   c. polar easterlies.

10. The Beaufort Wind Scale measures:

    a. how winds change.
    b. what direction the wind blows.
    c. how powerful the winds are.

11. An area of the world in which monsoons occur regularly is:

    a. Southeast Asia.
    b. South America.
    c. South Sea Islands.

12. Winds are caused by:

    a. forces trying to push air from a higher pressure to a lower pressure.
    b. forces trying to push air from a lower pressure to a higher pressure.
    c. the heating and cooling of the earth's surfaces at a consistent rate.

13. The larger winds are affected by:

    a. the earth's rotation.
    b. difference in temperature.
    c. both a and b.

14. What creates a monsoon?

    a. high pressure over mountains.
    b. low pressure over ocean and high pressure over land.
    c. high pressure area over the ocean and a low pressure area over the land.

15. Wind speed is recorded in:

    a. miles per hour (mph).
    b. miles per second (mps).
    c. knots.
    d. fathoms.

VOCABULARY SKILLS:

Define the following words according to the definitions in the text:

1. Coriolis Effect.
2. Temperate Zone.
3. Migratory lows.
4. Horse latitudes.
5. General Circulation.
6. Centers of action.

BRAIN TEASER

Find out how climate affects mode of transportation. Choose three different climatic regions of the world. Explain what mode of transportation you would use in each area and give reasons for your choice.

Collect old "weather sayings" and discuss if true or false.
Example: "Red sky at night, sailors delight."

Try to estimate wind speed and direction by seeing how it affects trees, flags, etc. Were you successful? What could you do to check your estimates?

FRONTS AND STORMS

** A front is a line that divides two different air masses. Its name depends on the type of air present and the direction the air is moving. **

You already know that an air mass is a large body of air that has a particular character: temperature and wetness. This character is shaped by the land surface or water surface over which the mass has formed and stayed, often for a long time. Over the earth there are many areas where such air masses collect. You might think of each such area as a weather machine getting ready to distribute its product. But, of course, these air masses do not stay still forever. They move. Once these air masses (or weather machine products) begin to move, each carries its brand of weather with it. And when these air masses crash into one another somewhere over the earth they have a fight for domination. Each air mass struggles to conquer the other. Until one air mass wins, the weather in the area will be bad.

A front is simply a line that divides two different air masses that have met in a head-on collision. When they meet in this collision, the area where they meet is called an area of convergence (air coming together). Because the two air masses are so different in character, they refuse to mix and begin warfare. The frontal line can be very long -- 50, 100, even 200 miles. The masses struggle against one another and refuse to mix. They are like oil and water.

A mass of cold air moves into an area dominated by warmer air. The fight begins. If the mass of cold air is large it will eventually dominate. It is heavier and pushes in, forcing the warm air upward.

Try to imagine yourself living in a city where this change in weather is occurring. What would you expect? It is a nice day. The air is warm and moist. There are cumulus clouds. But as the cold air mass begins to move in, the winds increase and the warm air is pushed upward. It rushes up quickly. Now the clouds look heavier and darker. As the front reaches the city, you are drenched with rain showers perhaps for two or three hours while the air masses battle.

Then the showers stop, the weather cools, the sky clears, and the air feels much drier. When a warm air mass approaches a colder stable mass of air, the warm air, being lighter, usually goes up over the cooler air. It is almost as if the warm air has to glide up a hill. It spreads out and the result is that sometimes 300 miles ahead of the center of the mass, there will be clouds, rain or snow.

You can see now why weather in the tropics or at the poles is much more unchanging than in the temperate zones. After all, for vast distances in the Tropics or in the poles the air mass is basically the same. But in the Temperate Zones, frontal (battlezone) weather is common.

The earth has primary areas where fronts are most likely to develop. These are the Intertropical Convergence Zone, the Arctic Frontal Zone, and the Polar Frontal Zone.

The first of these frontal zones is formed in the Doldrums, a zone of very light and irregular surface winds, occurring between the belts of the Trades in each of the hemispheres. In this zone, small air masses rise from the surface partly because of the high equatorial temperatures and partly because of the slight differences in air masses coming in from the northeast and southeast trades. Small differences in heat and therefore in weight cause one mass to be forced upward on top of the other. The result is a little front called an intertropical front. These fronts produce short thunderstorms called squalls. A sailor in tropical seas can often see four or five of these squalls in progress at the same time.

The Arctic Frontal Zone develops between the true arctic air of the far North and the polar maritime air of the North Atlantic and Pacific Oceans.

The Polar Frontal Zone is formed by convergence of the Polar Easterlies and the Prevailing Westerlies. In other words, this is the Temperate Zone and the polar front is the place where the battle between the cold polar air and the warm tropical air takes place. During the winter the contrast between the two masses is very strong and the heavier polar air fights its way farther south. When the polar air wins this battle during the winter, the southern United States experience what weathermen call a cold snap. What is a cold snap? It is nothing more than the dominance of polar air over previously dominant warmer tropical air. All these frontal zones, the Intertropical Convergence Zone, the Arctic Frontal Zone, and the Polar Frontal Zone, are, of course, permanent. They extend around the earth.

CONDITIONS OF A COLD FRONT

1. Darkening of the horizon to the west and to the north
2. Lowering of clouds and heavy rainfall for a short time
3. Shift of wind to a westerly direction
4. Rapidly clearing weather
5. Large drop in relative humidity.

Usually a cold front moves faster and more steadily than a warm front.

CONDITIONS OF A WARM FRONT

1. First, the appearance of cirrus clouds, then stratus clouds, and then some strato-cumulus clouds
2. Gentle rain or snow increasing in intensity
3. Just before the front passes, fog or low black clouds and continued light rain
4. Clouds lifting, rain or snow stopping
5. Temperature rising.

The warm front brings rain for a longer time. The rain covers a wider area and the rainfall is gentler.

CONDITIONS OF AN OCCLUDED FRONT

A cold front moves much faster than a warm front. So it often happens that the cold front overtakes a warm front in its path. Two conditions can occur.

Condition 1

The air at the front of the rushing cold air mass is usually much colder than the air at the back of the retreating warm air mass. In this case the cold air will run right under the warm air ahead of it.

Condition 2

But sometimes the air at the front of the rushing cold air mass is actually warmer than the air at the back of the retreating warm air mass. In this case the warmer air will run up over the cooler air. In both occluded conditions the weather will be violent and very wet.

THUNDERSTORMS

Scientists believe that thunderstorms mainly occur because of the height to which moisture-filled air is lifted. The air is lifted again and again until it forms huge, cauliflower-like clouds: giant cumulus and cumulo-nimbus clouds. These clouds are actually six or seven miles tall. Thunderstorms occur inside these. Within the giant cloud there is wild activity. Violent air currents rush up and down, sometimes going 100 mph. Violent winds pour out of the cloud as do flashes of lightning. The lightning causes claps of thunder. Inches of rain occur in only a few minutes.

A thunderstorm occurs in three stages: cumulus, mature, and anvil or dissipating.

The first or cumulus stage usually occurs during the early part of a very hot humid summer day. The earth heats, especially over surfaces like concrete or sand, and the air above these surfaces becomes warmer than over other surrounding areas like water. The air rises with its water vapor. As it rises it cools until the water condenses. This condensed water is the start of a cumulus cloud. Heat is released by the condensing water and so the air goes even higher and higher. This cloud grows and builds as the updrafts continue.

The mature stage is characterized by strong updrafts and strong downdrafts within the cloud. As the warm moist air keeps rising through the surrounding cool air, the cloud gets even larger and larger. Finally, the top of the cloud is towering several miles above the earth. Out of this giant pile of rushing winds and water and ice, all smashing against one another, come the thunderstorms. As the strong warm winds are blowing into the forward part of the storm, swift currents of colder air are rushing downward in drafts from the higher regions of the cloud.

The last stage is called the anvil or dissipating stage. It could also be called the cloud's old age. During this stage the downdrafts take over. Rain falls heavily, creates more downdrafts, and the storm becomes less violent. The giant thundercloud breaks up into broken stratus clouds with raggedy edges.

Inside the mature cloud, the wind currents surge up and down. These currents actually tear apart the water droplets that are being whipped around in the cloud. This tearing apart of the droplets sets up electrical fields in the highest parts of the cloud as well as in the lower parts. These are positive charges. In the middle of the cloud the charge is negative. A lightning bolt is produced by these charges much in the way a spark is produced by a spark coil. A first spark followed by a main spark leaps forward, both working their way from cloud layer to cloud layer, from cloud to cloud, and, sometimes, from cloud to ground.

One single lightning bolt may develop 12 million horsepower -- and travel one half mile in less than ten one millionths of a second!

The thunder we hear is the air surrounding the lightning bolt expanding so quickly it explodes. This is the crashing sound of thunder.

Thunderstorms are common in the southeastern United States, northern Brazil, and the monsoon lands of Southeast Asia.

TORNADO

The tornado is the most violent storm known to man. In fact, the winds of a tornado cannot be exactly measured because they destroy every wind-measuring instrument. No natural storm can match the tornado in causing destruction. No natural storm can match the tornado in its crazy, twisting path. In 1896 a tornado hit St. Louis. It caused $12 million in damage and killed 306 people. This same tornado tore up and destroyed an entire house but left a bench along an outer wall of the house -- untouched. The destructive and unpredictable tornado is usually only 300 to 400 feet across. It travels slowly and quickly moving at anywhere from 25 to 40 mph. However, the winds within the center of the tornado are very fast. They whirl around at speeds that often go over 300 mph.

Tornadoes grow only during thunderstorms. In fact, they are really one wind system at the end of a thunderstorm that drops off and increases in speed and size. Inside the tornado is a severe low-pressure area. In fact, if a tornado touches down to the ground over a closed building, the building will explode. It will explode because of the sudden difference between the high pressure inside and the lack of pressure outside. Within the center of a tornado there is a 100 to 200 mph updraft. Tornadoes have been known to suck up houses, steel girders, and even steam locomotives.

Tornadoes are most common in spring and summer. The center of the tornado area in the United States is eastern Kansas.

Over a lake or ocean a tornado funnel will suck up water and create a waterspout. The largest and most spectacular waterspout ever took place in 1896 in Martha's Vineyard off Massachusetts. This spout was about 240 feet in diameter at its base near the water and 840 feet in diameter at the cloud base.

TROPICAL CYCLONE (HURRICANES)

The tropical cyclone is a violent storm that forms as a spinning circle with winds of more than 74 mph whipping around a low pressure area. In the Northern hemisphere the winds blow counterclockwise; in the Southern, they blow clockwise. But the result in either hemisphere is a violent tropical storm. In fact, the tropical cyclone has so many degrees of strength it is subdivided into three types according to how fast their winds are blowing:

1. a Tropical depression -- maximum wind, less than 34 knots
2. a Tropical storm -- maximum wind, 34-63 knots
3. a Hurricane or Typhoon -- maximum wind, 64 knots and up.

There are areas in the world where atmospheric conditions are perfect for the storms to breed. Each area is over an ocean. These are in the northern Atlantic and Pacific Oceans, in the Indian Ocean, and in the China and Arabian Seas. And wherever the cyclones occur the people have given them names that show their power. Off the coast of Florida they are called hurricanes. The word "hurricane" perfectly shows the people's fear of these storms. It comes from the name, Huracan, the West Indian God of the storm. The cyclone in its strongest form is, indeed, the god of storms.

If you were to gather two trillion tons of air, stuff them into a circle of about 300 miles, and spin them at about 100 mph you would have the outline of a hurricane. Put this giant whirlwind over an ocean which it stirs up to 20, 30, and 40-foot waves, fill this air with giant water-soaked clouds that drop 15 inches of rain in 24 hours, watch this storm move along at 12 mph destroying almost everything in its path and you have imagined a grown hurricane.

Of course, the hurricane does not develop all at once. Like other weather systems it takes time to grow. Hurricanes are born in the low latitudes where there is plenty of warm tropical air. This air heats and rises, creating a strong, low-pressure area. Air masses from surrounding highs rush in and because of the earth's spin (this is the zone of the Westerlies), the rushing air takes on a strong spinning motion. Meanwhile, the huge clouds are forming and closing. Picture the air as the water in your bathtub being sucked down the drain and you will get an idea of the motion. Like all living creatures, the hurricane must eat to live and to grow stronger. Here is why the ocean is so important to the hurricane's development. The hurricane's food is the ocean. It continues to supply the hurricane with water.

This water is quickly changed into water vapor, which is condensed into water droplets. As you know, this water vapor is filled with energy. The more the water vapor condenses, the more it releases heat to the spinning air. And the air rises even more quickly. In short, the more tropical air, the more condensation, the more wild energy. The cycle will not end until something happens to change the direct source of the energy. This "something" is the hurricane changing its path.

It is hard to understand how much energy the hurricane carries. You can get some idea if you realize that in one hour the hurricane releases more energy than 700 Hiroshima atomic bombs -- put together!

To ships at sea there is no storm that is more frightening than the hurricane. During World War II, Admiral Halsey's Third Fleet was trapped inside a typhoon, 500 miles east of Luzon, the main island of the Philippines. Battleships, carriers, and destroyers were tossed around like match sticks. Every ship was damaged; three were sunk. Most survived because they could maneuver and at least could try to avoid the middle areas of the storm where conditions are always worse. Also, if Halsey could have known of the hurricane's path early enough, he might have been able to maneuver out of the way. Knowing that the winds blow counterclockwise in the Northern hemisphere and clockwise in the Southern hemisphere you have a chance to avoid the storm by using the winds to steer your ship on a safer course.

Islands caught in the path of a hurricane cannot move. Such islands can be totally destroyed with trees ripped off at their roots, beaches washed away, and houses washed into the ocean by the winds and crushing tidal waves.

In the Northern hemisphere, hurricanes move westward from their starting point (figure 3-15). They then curve to the northeast. In the Southern hemisphere they move eastward, then curve southwest. These winds can get up to 200 mph. Strangely, at the very center, called the eye, the weather is quiet with light winds, a little drizzle, and clear skies. Many persons have been killed when they found themselves in the eye of a hurricane and thought the storm was over. Leaving their shelters, they were suddenly hit by the other side of the storm.

Hurricanes grow in strength as they move along until they begin their curve to the northeast. When they change their direction, they move over cooler water or over land, and into cooler air. Cooling reduces the internal action of the storm and it lessens in power.

Hurricanes occur from June to December. They occur most often in September and October. The general path starts in the Doldrums. The hurricane travels west to north and northeast. You can see why it makes its curve. At about 2,000 miles north of the equator it is caught by the Prevailing Westerlies. The east coast of the United States is often threatened by hurricanes because the hurricanes reach the coast before storms have curved away. Even if the hurricane does not strike the coast, the weather it brings is so violent and widespread it can soak from Philadelphia to Massachusetts and create floods from Georgia to Virginia.

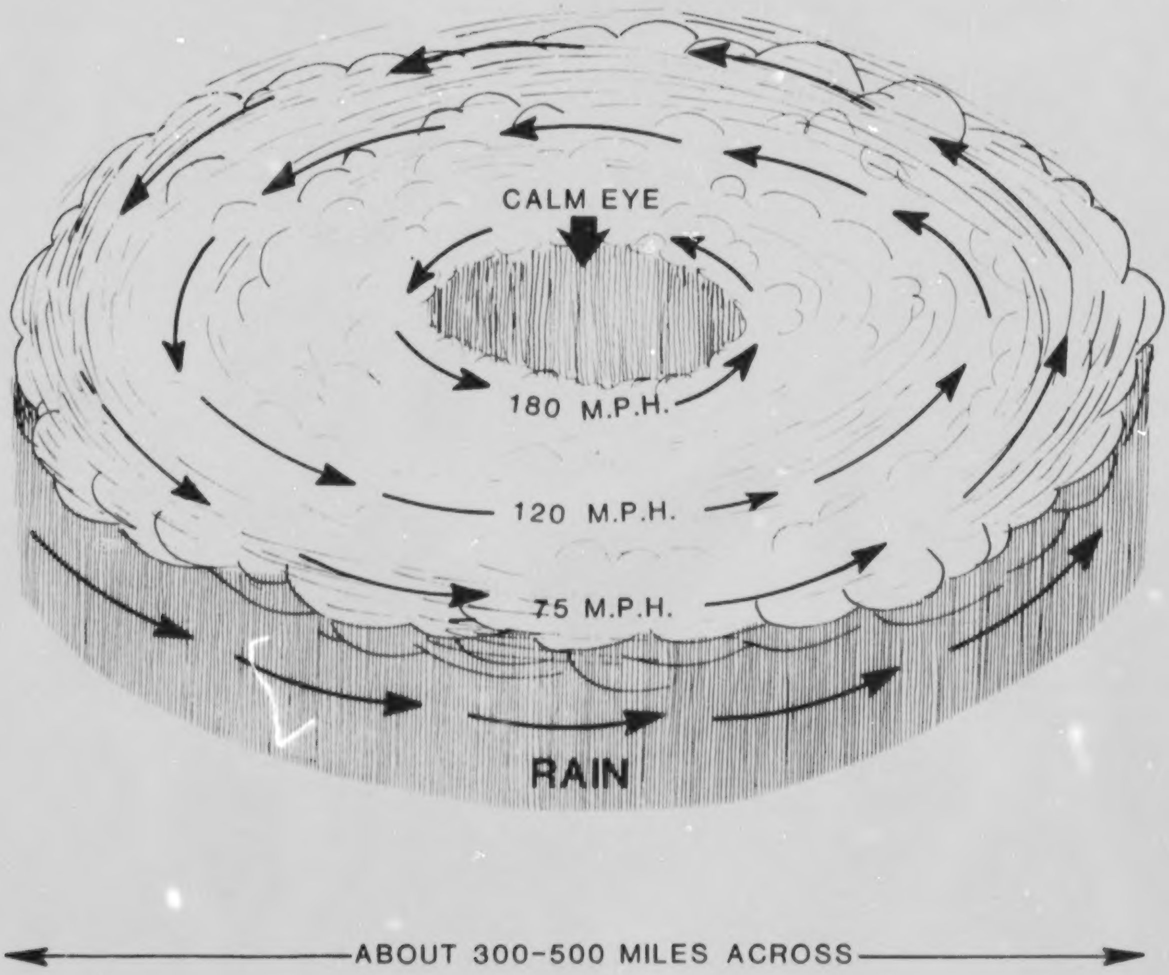


Figure 3-15. A Hurricane

There are certain definite signs of an approaching hurricane. During the "hurricane season" navigators are constantly on the lookout for these signs.

THE SIGNS OF AN APPROACHING TROPICAL CYCLONE AS THEY MIGHT OCCUR FROM MOMENT TO MOMENT:

1. during the hurricane season, any major change in barometer readings
2. any occurrence of a long, low swell (long, low non-breaking waves). The swell's direction shows the bearing of the storm's center:
    a. light, feathery plumes of cirrus clouds appearing just before the swell begins and these fanning out from a whitish arc on the horizon
    b. sky becoming more and more overcast until the dark hurricane clouds appear on the horizon
3. barometer beginning a steady fall; air becoming heavy, hot and moist; winds picking up
4. humming sound (caused by increased wind speed)
5. fine, misty clouds of rain breaking off the main clouds; rains increasing to heavy showers, heavy showers increase to sheets of rain
6. sea beginning to roll in mountainous waves (60 ft. high).

Because severe storms are the greatest danger to ships, the National Weather Service hoists flags and pennants to indicate either the approach or presence of bad weather.

Small Craft Warning: One Red pennant displayed by day, and a red light over a white light at night, indicate that winds of up to 38 mph (33 knots) and sea conditions dangerous to small craft are forecast in the area

Gale Warning: Two red pennants displayed by day, and a white light above a red light at night, indicate that winds ranging from 39 to 54 miles an hour (34-47 knots) are forecast

Storm Warning: A single square red flag with a black center displayed during daytime, and two red lights at night, indicate that winds of 55 mph (48 knots) and above are forecast

Hurricane Warning: Two square red flags with black centers displayed by day, and a white light between two red lights at night, indicate that winds of 74 mph (64 knots) and above are forecast for the area.

The invention of the Satellite has decreased the chances of a hurricane striking an area without enough advanced warning. The storm is spotted as it develops and bulletins on its progress and strength are broadcast to all those who may be in danger. Ships and aircraft can maneuver to avoid the storm; people have time to leave endangered areas or to fortify their homes against the God of Storms.

STUDY QUESTIONS:

1. Where are the primary areas where fronts are most likely to develop?

   a. ________________

   b. ________________

   c. ________________

2. In what zone do squalls occur?

   ____

3. From the description in the written material, draw the three stages of a thunderstorm as you understand it.

   a) b) c)

4. Lightning develops in a thunderstorm by the electrical charges moving between clouds, within clouds or to the ground. True or False.

5. Why does thunder occur?

   a. expanding air.
   b. contracting air.
   c. electrical shock.

6. What is the most violent storm known to man?

   a. tornado.
   b. thunderstorm.
   c. depression.

7. Tornadoes grow only during:

   a. winter.
   b. thunderstorms.
   c. tropical cyclones.

8. How is a tornado different from a cyclone?

   a. common in spring and summer.
   b. originates from a thunderstorm.
   c. both a and b.

9. What are the three types of cyclones?

   a. ____________________

   b. ____________________

   c. ____________________

10. Where are hurricanes born?

    a. Bermuda Triangle.
    b. low latitudes, over the ocean.
    c. equator.

11. In which direction does the wind of a hurricane blow?

    Northern Hemisphere ____________________

    Southern Hemisphere ____________________

12. Illustrate the motion of a northern hemisphere hurricane and direction of movement. .

13. Name three influences on the development of a hurricane.

    a. ____________________

    b. ____________________

    c. ____________________

14. The boundary formed when warm, moist air replaces cold, dry air is called:

    a. cold front.
    b. warm front.
    c. occluded front.

15. Study the words below and cross out the word in each line that is not related to the other two.

    1. waterspout, tornado, tropical depression.

    2. front, convergence, hurricane.

    3. intertropical front, cold snap, squall.

    4. fog, eye, hurricane.

WORD SEARCH

Each of the words below is hidden in the puzzle. Find and circle them. Words may be forward or backward and may be vertical, horizontal or diagonal.

P	O	N	T	B	N	O	I	T	A	R	I	P	S	N	A	R	T
C	P	F	B	A	R	O	G	R	A	P	H	V	E	U	I	N	P
B	S	A	C	R	N	H	G	L	Z	X	O	T	N	O	R	F	O
A	Y	H	O	O	S	I	F	R	A	D	S	A	T	J	I	H	L
N	C	R	A	M	N	F	O	D	A	I	K	Q	I	M	J	M	I
R	R	E	L	E	C	R	I	C	G	M	C	E	U	I	C	G	T
G	O	N	E	T	A	R	O	O	I	K	E	J	H	A	E	R	L
S	M	H	S	E	E	N	L	N	C	Y	L	O	N	T	L	M	E
A	E	E	C	R	D	O	R	V	B	D	C	J	N	A	L	L	B
Q	F	I	E	E	R	B	I	E	N	E	I	A	E	C	O	L	N
B	E	T	N	O	M	R	B	C	I	J	U	O	R	S	N	O	E
L	R	S	C	C	R	S	A	T	H	E	S	B	R	A	R	A	L
N	E	T	E	O	A	I	T	I	R	M	T	H	Y	E	I	M	L
I	E	Y	A	N	I	G	E	O	I	E	E	R	M	A	N	O	A
M	H	A	C	I	C	H	L	N	O	I	T	C	E	V	D	A	N
U	P	P	A	Y	C	O	R	U	N	U	Z	S	Q	R	E	R	A
H	U	M	I	D	I	T	Y	E	F	Z	Y	U	I	R	L	G	V

WORDS TO FIND:

TRANSPIRATION
BAROMETER
FAHRENHEIT
COALESCENCE
CONDENSE
HUMIDITY
BAROGRAPH

FRONT
SQUALL
CELSIUS
ANEROID
VAN ALLEN BELT
ADVECTION
CONVECTION

VOCABULARY SKILLS:

Define the following words according to the definition given in the text.

1. Front
2. Squall
3. Convergence
4. Cold snap
5. Waterspout
6. Eye of a hurricane

BRAIN TEASERS:

Boston fishermen worry about hurricanes coming from Florida. Great Lakes fishermen worry little about them. Why is this?

Investigate the services the weather bureau provides in your area.

Make a report to the class on hurricanes, tornadoes, cyclones, squall lines and blizzards. Explain the differences between them.

List the radio and television stations in your area and the time each broadcasts the weather forecast. Tell how weather warnings are given by each station.

CHAPTER IV: ASTRONOMY

Astronomy, the scientific study of the universe, has held man's interest since the dawn of time. Ancient man looked up at the sun, the moon, the stars at night and asked:

What are they made of?

What explains their location and their movement?

What influence do they have on us here on the earth?

Besides satisfying his curiosity, man found particular uses for his developing knowledge of these heavenly bodies. He could use this information to help him set his course at sea, to tell the time of the day and the seasons of the year. He used it to make more and more accurate pictures of the universe. And in modern times he learned to use this knowledge to guide him in journeys through space.

Along with his increasing knowledge of the universe, man invented new tools for increasing the distance and accuracy of his observations. He learned how to use his new knowledge of electronics, photography and space travel in making better, newer tools to aid his astronomical observations.

THE TOOLS OF ASTRONOMY

** Astronomy uses a variety of tools to increase our knowledge of the universe: the eyes, the mind, the imagination, telescopes, spectrographs, radio and radar telescopes, high-altitude balloons, sky labs and space probes. **

The eyes, mind and imagination of man were the original tools of astronomy. Since then, many new tools have been designed, some of them costing millions of dollars. But man's mind remains the key tool in understanding the wealth of information gathered by these new tools. These tools range from optical extensions of man's eye (telescopes) to elaborate instrument packages that journey through space (space probes).

TELESCOPE

Anyone who has looked through a *telescope* knows that it uses a series of mirrors and lenses to collect light from a distant source. The collected light, the image, is then magnified so that it can be analyzed in much greater detail than by use of the naked eye. *Galileo* (1564-1642), the Italian scientist, was the first to use a telescope to observe heavenly bodies (figure 4-1). Modern research telescopes are much larger, more complex, and more powerful than Galileo's small instrument. These large telescopes are housed in observatories located in *remote* places in order to avoid the night-time glare and air pollution of large cities. Elaborate equipment aims these heavy telescopes and keeps them on target. They record the collected images on photographic plates. These plates become a permanent record that can be analyzed in great detail by researchers.

SPECTROGRAPH

The light collected by a research telescope can also be processed and recorded by a *spectrograph*. Anyone who has seen a *prism* split a beam of sunlight has a basic understanding of this process (figure 4-2). The prism splits the sunlight into a rainbow of violet, indigo, blue, green, yellow, orange, and red. The image of this split-apart sunlight is called a *spectrum* or in its plural form *spectra*. Other light can also be analyzed by the spectrograph. The spectrum of a star looks like a horizontal bar with a series of narrow vertical lines located at various points along the bar. The number and location of these vertical lines give scientists important information about the physical makeup and activity of the star. The spectrograph, an instrument for making photographs of spectra from various light sources, is not limited to visible light. It can also record spectra produced by infrared and ultraviolet light. It opens a window in the universe much wider than the narrow slit of man's eyes.

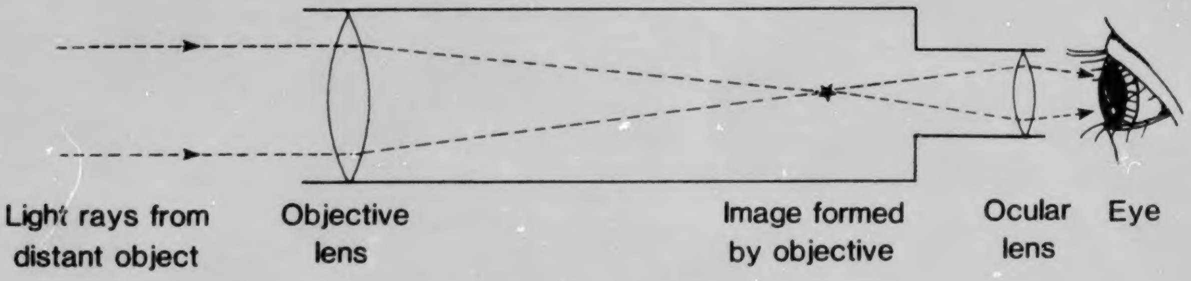


Figure 4-1. A Simple Reflecting Telescope

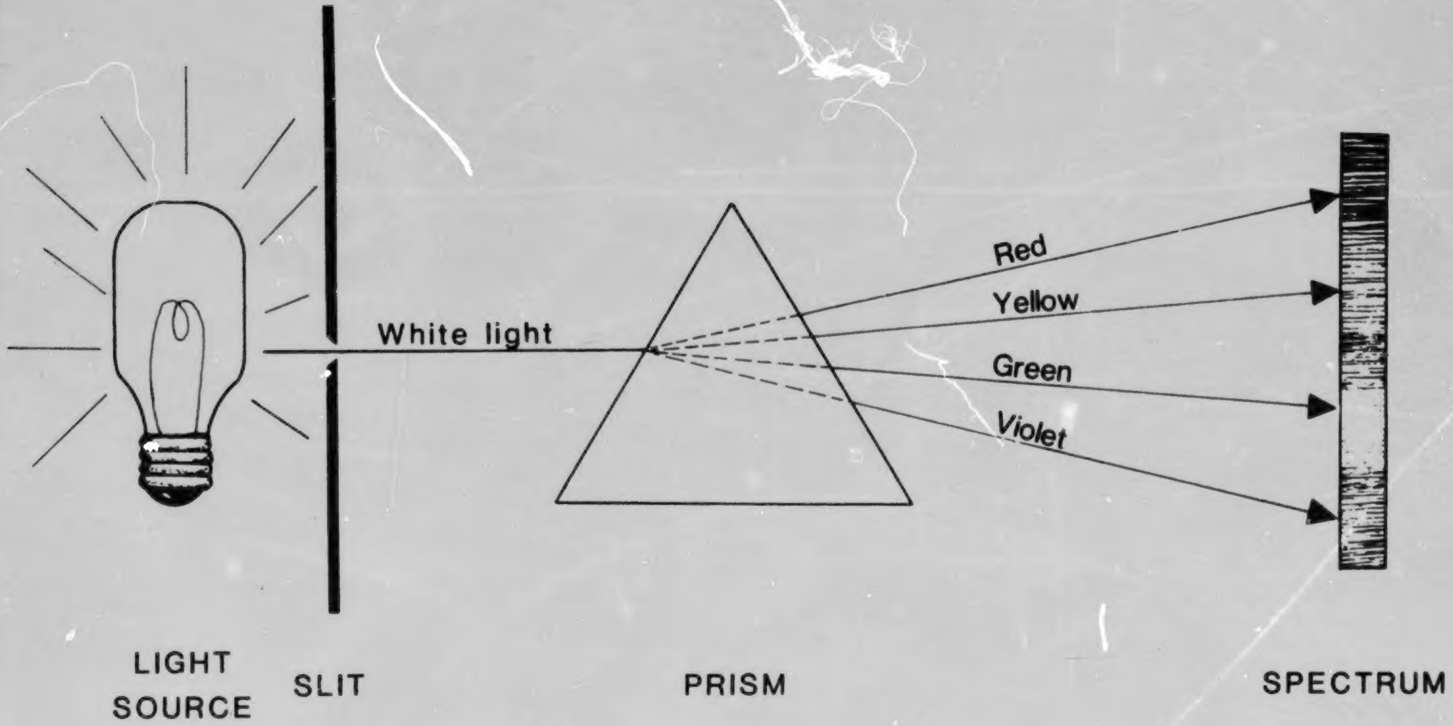


Figure 4-2. Light Bent by Prism

RADIO AND RADAR TELESCOPES

Radio telescopes use very large antennae to trap and measure radio-frequency radiation from the stars. Radar telescopes operate differently. They aim radar pulses at the planets. These pulses bounce off the target, return to earth, are picked up by the telescope's antenna, and are then analyzed. Radio and radar operations are frequently combined into a single installation. One of the largest radio/radar telescopes is the gigantic installation at the National Astronomy and Ionosphere Center (Arecibo, Puerto Rico). It has a mammoth reflector dish, 1,000 feet in diameter, with transmitting and receiving instruments suspended 600 feet above the dish. This telescope can be used to make accurate maps of Mercury, Venus, and Mars. It can be used to study pulsars (pulsating radio sources) deep in space. It will be used in detecting and classifying as many as 100,000 cosmic radio sources.

HIGH-ALTITUDE BALLOONS, SKYLABS, SPACE PROBES

The earth's atmosphere protects us from harmful heat and radiation; but it also interferes with visible light that reaches the earth and it also filters out many kinds of radiation. If scientists can lift their instruments high in the atmosphere or free them from the earth, then it stands to reason that the quality of the observations will be greatly improved. This freedom is possible through the use of high-altitude balloons, skylabs (orbiting observatories), and space probes. Balloons are the least expensive and most practical, but space probes are the most exciting because they bring men closer to distant and mysterious planets than ever before. The two Viking Landers that explored Mars in 1976 are good examples of space probes that caused worldwide excitement. They carried a variety of cameras and for the first time showed a close-up view of the Martian landscape: a flat plain covered with sand and boulders. Above the plain they showed a brilliant salmon-pink sky. They measured wind velocity and temperatures. They reached out with mechanical arms and scooped up Martian soil for chemical analysis. The soil produced puzzling reactions but did not prove what some had hoped, the existence of life on Mars.

These powerful tools have given modern astronomers a wealth of information never imagined by the first men who looked up at the stars in wonder. The picture, even now, is far from complete. In the next section we will summarize what astronomers have learned about the universe, the stars and our own solar system.

FILL IN BLANKS:

1. ________________ makes photographs of light from various light sources.

2. ________________ collects and measures radio-frequency radiation from various light sources.

3. ________________ uses a series of mirrors and lenses to collect light from a distant source.

4. ________________ bounces radar pulses off the planets. Collects and analyzes them.

TRUE OR FALSE QUESTIONS:

Write T if the statement is correct. Write F if it is incorrect, and then rewrite the sentence to make it correct.

_____ 1. Ancient man used the stars to accurately predict the weather.

_____ 2. The first observations of the sky using a telescope were made by Galileo.

_____ 3. In 1976 the Viking Landers explored the moon.

_____ 4. Sand samples analyzed by the Viking Landers proved that life once existed on Mars.

_____ 5. The type of light above the atmosphere gives the astronomer more complete information than does light he can observe from earth.

_____ 6. Observatories are located in remote places to avoid noise pollution.

_____ 7. The spectrograph uses a prism to split light into a spectrum of colors.

_____ 8. All telescopes use lenses.

ANALOGIES:

From the words below choose the ones needed to complete the analogies and write them in the blanks.

1. The lens is to the telescope as the _________ is to the microscope.
2. The astronomer is to the stars as the _________ is to living things.
3. The _________ is to the planetarium building as the telescope is to the observatory.

botanist
projector
mirror
lens
biologist
spectra

VOCABULARY SKILLS:

Define each of the following words used in the text. Then write an original sentence using each word.

1. Telescope
2. Galileo
3. Spectrograph
4. Spectrum
5. Spectra
6. Radio Telescope
7. Radar Telescope
8. Prism
9. Pulsar
10. High-Altitude Balloons
11. Viking Lander
12. Remote

WORD SEARCH

Each of the words at the bottom are hidden in the puzzle. Find and circle them. Words may be forwards or backwards, and may be vertical, horizontal or diagonal.

A	K	J	F	N	E	W	Y	K	I	M	N	O	P	X	Q	Z	R	S
B	S	L	M	N	K	E	V	W	N	I	Z	V	K	X	L	G	C	P
N	B	P	B	L	X	O	L	I	G	H	T	Y	E	A	R	S	O	E
K	I	H	E	A	I	F	S	T	R	E	E	S	W	I	M	L	N	C
I	K	P	P	C	F	H	A	P	S	E	S	K	Y	L	A	B	S	T
B	M	Y	A	D	T	P	Y	U	A	I	A	T	I	S	T	E	T	R
O	N	G	A	M	P	R	A	L	E	C	G	O	A	N	I	N	E	A
Z	C	I	J	I	I	U	K	L	R	E	P	E	R	N	T	O	A	R
W	E	L	M	C	R	N	R	U	Y	A	D	R	O	O	T	H	T	P
V	G	E	A	R	A	I	R	M	E	T	P	A	N	E	B	N	I	N
M	F	O	R	I	S	V	O	I	M	E	E	H	O	I	G	E	O	I
E	K	E	I	T	O	E	F	N	M	L	Y	I	M	H	T	A	N	M
G	A	L	A	X	Y	R	I	O	E	E	O	N	Y	N	D	I	S	K
F	Z	E	Q	B	F	S	N	S	D	S	J	I	M	C	O	I	H	E
K	Y	U	A	E	O	E	F	I	V	C	I	H	P	Y	R	T	I	P
L	X	L	S	D	S	A	I	T	N	O	G	T	I	P	S	W	O	O
N	N	C	L	O	T	T	O	Y	R	P	N	O	N	G	R	A	S	N
C	Y	I	K	U	W	M	O	J	N	E	N	B	O	S	P	Q	R	T

GALAXY
TELESCOPE
SPECTROGRAPH
CONSTELLATIONS
LUMINOSITY
ASTRONOMY
UNIVERSE

SPACE PROBE
PRISM
LIGHT YEARS
SPECTRA
STARS
SKYLAB
GALILEO

21

WORD PUZZLE:

Identify the missing letters which are represented by numbers in the words below.

Write the missing letters in the numbered blanks. (Clue: Galileo was one of these.)

Spectr1
2pectrograph
3elescopes
Pulsa4
Radi5 Telescop9
Viki6g Lander
10adar Telesc7pe
Pris8

1 2 3 4 5 6 7 8 9 10

BRAIN TEASERS:

1. Make a detailed study of one of the tools of astronomy. Write a brief explanation of the way it works. Include charts and/or drawings to illustrate your explanation.

2. Visit a planetarium if there is one in your area.

3. Make a simple spectroscope.

   Materials: Cardboard tube such as a paper towel tube
   Replica refraction grating (available from Edmond Scientific Co., Barrington, NJ)
   Heavy aluminum foil

   Instructions:

   a. Glue refraction grating across one end of tube.

   b. Fasten foil on other end with rubber band. Cut a straight narrow slit in the foil.

   c. Look at various kinds of light: sunlight, incandescent, fluorescent, etc. What differences do you observe? What conclusions about light can you come to?

4. Galileo lived during the 16th century in Italy (about the same time that Shakespeare lived in England). The men were still riding horses, fighting with swords and primitive guns. Many still believed in witches and goblins. What effect do you think his discovery of the telescope might have had on the people of Galileo's time? Why? Do you think that the invention of a revolutionary scientific instrument or process usually has the same effect? What about in medicine?

5. Read about the Andromeda Galaxy and brief the class on your findings. Cite any science fiction you may know of related to this.

6. View the television program Cosmos with Carl Sagan if it is available in your area. Discuss it briefly on the class day following the program.

7. Make constellation charts on 8 X 10 cardboard. First draw the space constellation, then punch a hole with a pencil where each star should appear. When you hold the cardboard up to a light bulb in a dark room you can see constellation much the way it appears in the sky. Have each person in the class do one and tell what inspired its name.

8. Read about Hoyle's steady state universe theory. Also read about the creationist theory. In a class discussion compare both of these to the "big bang" theory.

9. Discuss the possibilities of space travel in science fiction you have read or seen. How do the authors manage to convince you that beings from different star systems can meet?

THE UNIVERSE

** A map of the universe would show stars clustered in galaxies shaped like spirals or ellipses. Our own galaxy, one among many, contains about 400 billion stars. Ancient man grouped the stars into constellations and gave them names. Modern astronomers classify stars according to their real brightness, including our sun, using the Hertzsprung-Russell (H-R) Diagram. **

In studying the universe, astronomy looks first to its countless stars, trying to locate them, compare them, understand them, and relate them to our sun. These stars are hot gaseous globes that radiate electromagnetic energy and visible light. They produce this energy through an atomic reaction much like nuclear fusion. Fusion occurs when two atomic nuclei join together to form one. The sun is a giant furnace that converts mass into energy. Every second tons of hydrogen are transformed into helium, releasing incredible amounts of energy in the process. Our sun is just one of countless stars, but all-important to us because we depend on it for heat and light.

"BIG BANG" THEORY

A map of the universe would show the stars clustered in galaxies shaped like spirals or ellipses. These galaxies are rapidly moving away from a central point where they began. This motion suggests to astronomers that the universe began in an enormous explosion, the "big bang." George Gamow, an American physicist, has proposed that according to this big bang theory, matter was originally contained in a compact sphere which suddenly exploded. After the explosion, fiery matter rapidly expanded and then later condensed into the stars that form the galaxies. This is also known as the expanding universe theory. This explosion may have taken place as long as 10 or 20 billion years ago. Like this time scale, the number of galaxies and the distances involved leave the mind numb when we try to visualize them in our imagination. And our map of the universe would have no definite boundaries, because astronomers do not know its overall size and shape.

OUR GALAXY

Our own galaxy, one among many, contains about 400 billion stars. These stars are arranged in arms that spiral from a central hub. Our sun is located in one of these arms, about 30,000 light years from the center. (A light year is used to estimate stellar distances. It is the distance that light travels in a year; about 9.5 million kilometers.) The distance across our galaxy is 100,000 light years, and our galaxy is 20,000 light years thick at its central hub. On clear nights we can look up and see a thick band of stars we call the Milky Way. When we do this we are looking across our galaxy toward its central hub, and we get a faint sense of the vast distances and large numbers of stars contained in our own galaxy. You can see why science fiction writers must invent "speed-time warps" to write stories about travelers from one galaxy entering another. At present, any logical travel time would make such visits impossible.

THE STARS

One of the tasks of modern astronomy is to locate as many of these stars as possible, most of them invisible to the naked eye. Besides locating these stars, the astronomer names them, classifies them, and groups them into useful patterns. Ancient man imagined that the stars he could see were located on a sphere that circled the earth far in space (figure 4-3). He arranged the stars into constellations and assigned them names based on the earthly shapes he imagined them to have. He also made up stories about how they got there. For example, Ursa Major (the name means Big Bear) is one of the best known constellations in the northern latitudes. We also call it the Big Dipper or the Plough. Each name suggests a different story of origin. Ancient man was also interested in the relative brightness of the stars. He noticed differences in the color of the light he saw, and he recorded the motions of the objects he observed. The stars seemed to move all together as if they were somehow attached; so he imagined that they were fixed in their celestial sphere and that the sphere moved as a whole. The planets, he noticed, were erratic in their motions, and he named them wanderers. Thus, ancient man created a simple and useful system for locating and grouping the stars overhead. This system is still employed by amateur astronomers who use the night sky as their laboratory and a simple telescope as their main tool.

Professional astronomers use a more exact and accurate method to classify the stars. They calculate a star's luminosity (absolute or real brightness, apart from the way we see it on earth). They combine a star's luminosity (brightness) with its spectral characteristics to accurately

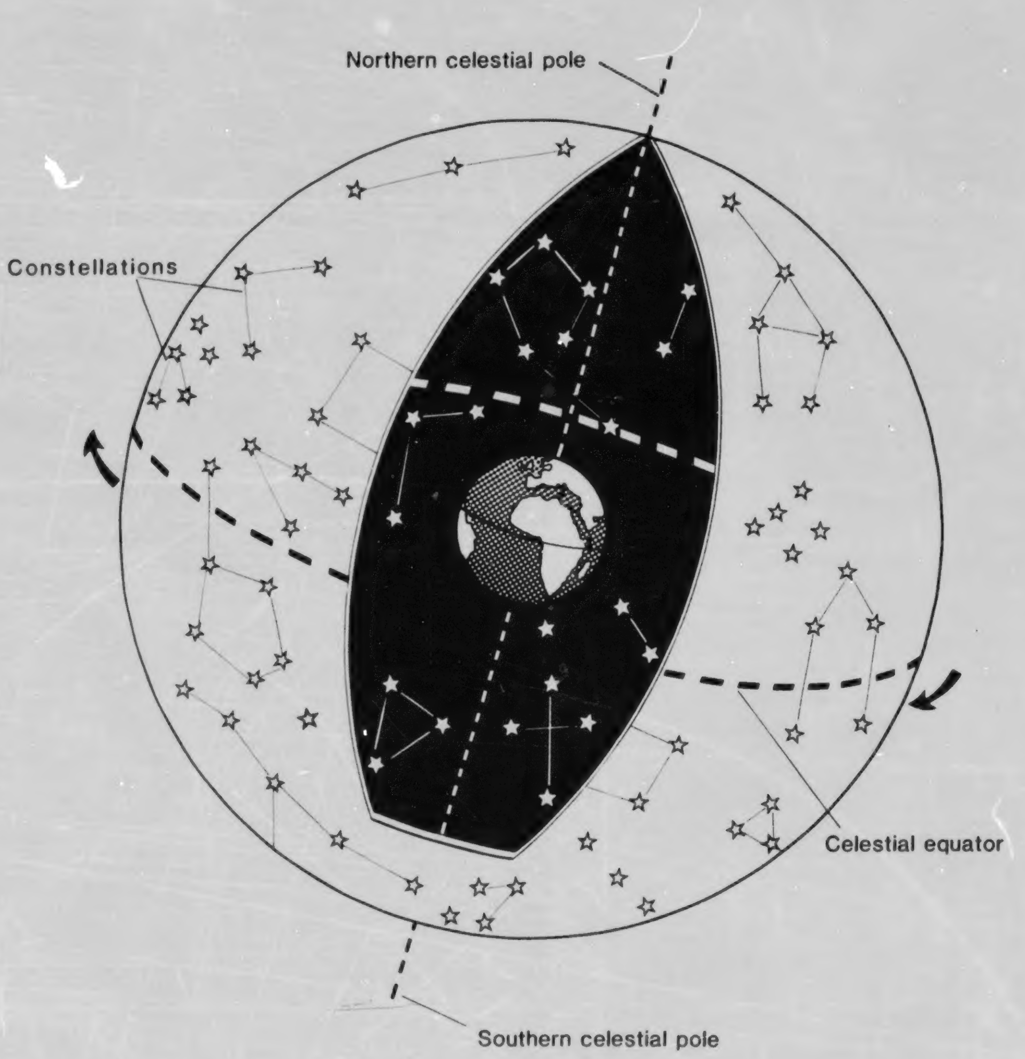


Figure 4-3. The Celestial Sphere

place it on a special graph. By looking at the Hertzsprung-Russell Diagram we can see how this works (figure 4-4). The H-R Diagram is a graph prepared independently by Danish astronomer Ejnar Hertzsprung and American astronomer Henry Russell which shows the relationship between luminosity or brightness (absolute magnitude) and temperature (spectral class) of a star. A star is placed from top to bottom depending on its luminosity. The brighter stars are closer to the top (-8, the very brightest), while the dimmer stars are closer to the bottom (16, the very dimmest). From left to right the stars are placed according to their spectral characteristics, with ultraviolet on the far left and infrared on the far right. The H-R Diagram allows scientists to group and compare large numbers of stars including our sun.

The H-R Diagram reveals several related groups or families of stars. The various groups of giant stars (Supergiants, Giants, and Subgiants) are remarkable for their large size, many times the size of our sun. Our sun belongs to a group of stars called main sequence stars. It emits a yellowish light. Although it is by far the largest, brightest, and hottest object we see with the naked eye, if we compare it to other stars on the H-R Diagram we see that it has relatively low luminosity, small size, and average temperature. Near the bottom of the H-R Diagram we see a group of stars called White Dwarfs because of their color, low luminosity and small size.

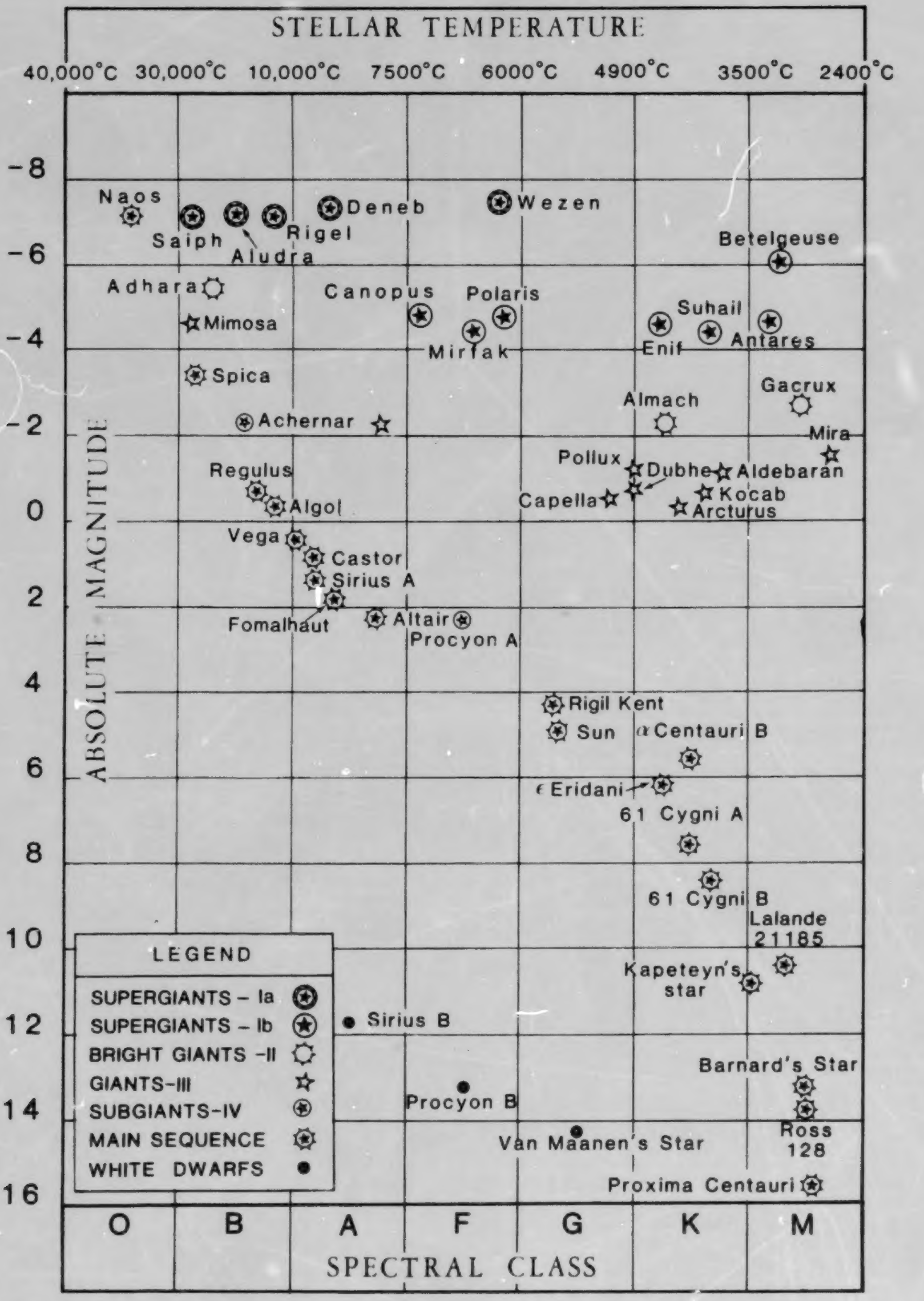


Figure 4-4. The Hertzsprung-Russell Diagram

MULTIPLE CHOICE QUESTIONS:

1. Of the following groupings, the largest is:

    a. galaxy
    b. solar system
    c. universe
    d. earth - moon system.

2. The unit used to measure stellar distances is the:

    a. mile
    b. parsec
    c. light year
    d. kilometer.

3. A grouping of stars that forms a pattern in the sky is called:

    a. galaxy
    b. solar system
    c. constellation
    d. asteroid belt.

4. Nuclear fusion occurs when:

    a. two nuclei are joined together
    b. a nucleus is split apart
    c. an atomic bomb detonates
    d. the sunspots reach a peak.

5. The sun's energy is the result of:

    a. fusion of helium atoms
    b. fusion of hydrogen atoms
    c. fission of helium atoms
    d. fission of hydrogen atoms.

6. The Milky Way is:

    a. one of the first constellations identified by man
    b. the name of our galaxy
    c. the name of the universe
    d. a dairy.

7. The magnitude of a star depends on:

    a. its size
    b. its distance
    c. its temperature
    d. all of the above.

8. The sun is:

    a. the largest star
    b. earth's closest star
    c. the brightest star
    d. a super giant.

9. Our sun is classified as a:

   a. supergiant
   b. subgiant
   c. main sequence
   d. white dwarf.

10. Stars are placed on the H-R Diagram from left to right on the basis of:

   a. brightness
   b. luminosity
   c. size
   d. spectra characteristics.

TRUE OR FALSE QUESTIONS:

Write T if the statement is correct. Write F if it is incorrect, then rewrite it to make it correct.

_____ 1. Our sun is a yellow star.

_____ 2. The brightness of a star is called luminosity.

_____ 3. Stars vary in brightness but are all the same color.

_____ 4. Our galaxy contains about 400 billion stars.

_____ 5. All stars are believed to be made of hot gases.

_____ 6. Through the process of fusion, the sun radiates tremendous amounts of electromagnetic energy.

_____ 7. The Hertzsprung-Russell Diagram is a way of grouping constellations.

_____ 8. Our sun is one of the largest stars on the H-R Diagram.

_____ 9. The magnitude of a star refers to its size.

_____ 10. According to the H-R Diagram, main sequence stars are the largest.

VOCABULARY SKILLS:

Define the following words in the text. Then write an original sentence accurately using each word.

1. Electromagnetic Energy
2. Nuclear Fusion
3. Main Sequence Stars
4. Big Bang Theory
5. Light Years
6. Galaxy
7. Milky Way
8. Constellation
9. Luminosity
10. Supergiants
11. Giants
12. Subgiants
13. Hertzsprung-Russell Diagram

WORD PUZZLE:

Identify the missing letters which are represented by numbers in the words below. Write the mssing letters in the numbered blanks. Find a science fiction movie title.

E112c1romagneti7

4ig Bang T23ory

5uminosity

Constel16ti10n

Mil8y Way

9ertzsprung-Russel11 Diagram

1 2 3 4 5 6 7 8 9 10 11 12

OUR SOLAR SYSTEM

** Our solar system has the sun (a star) at its center and nine planets around it. Some of these planets have satellites like our moon. **

Our sun and the nine planets that circle it form a system located on one of the arms of our spiral galaxy (figure 4-5). The sun exerts a strong gravitational pull on its nine planets, holding them in elliptical orbits around it. Mercury, the nearest planet, orbits the sun in only 88 days. Pluto, the most distant, takes over 240 years to complete its orbit.

The planets vary in relative size. The four closest to the sun -- Mercury, Venus, Earth, Mars -- are relatively small. The next four in sequence are larger: Jupiter (the largest), Saturn, Uranus, and Neptune; Pluto, the last planet, is very small. The distance of the earth from the sun, 93 million miles, is used as a unit of measurement by astronomers. We can use it to give a picture of the placement of the planets in the system. Let's assume that the earth is only 9.1 meters from the sun. Then the other planets would be placed as follows:

PLANET	DISTANCE (IN METERS) FROM THE SUN
Mercury	3.6
Venus	6.4
Earth	9.1
Mars	13.7
Jupiter	45.7
Saturn	86.8
Uranus	173.7
Neptune	274.3
Pluto	356.6

Now that we have a rough picture of the placement of the planets, we can watch them in orbit. If we imagine ourselves directly above the sun, we can watch them orbiting the sun in a counter-clockwise direction. The planets also spin on their own axes like tops in a counter-clockwise direction. The single exception is Venus, which rotates on its axis in a clockwise direction. Saturn is unique because it has a beautiful set of rings. If we look at the large space between the orbits of Mars and Jupiter, we will see a

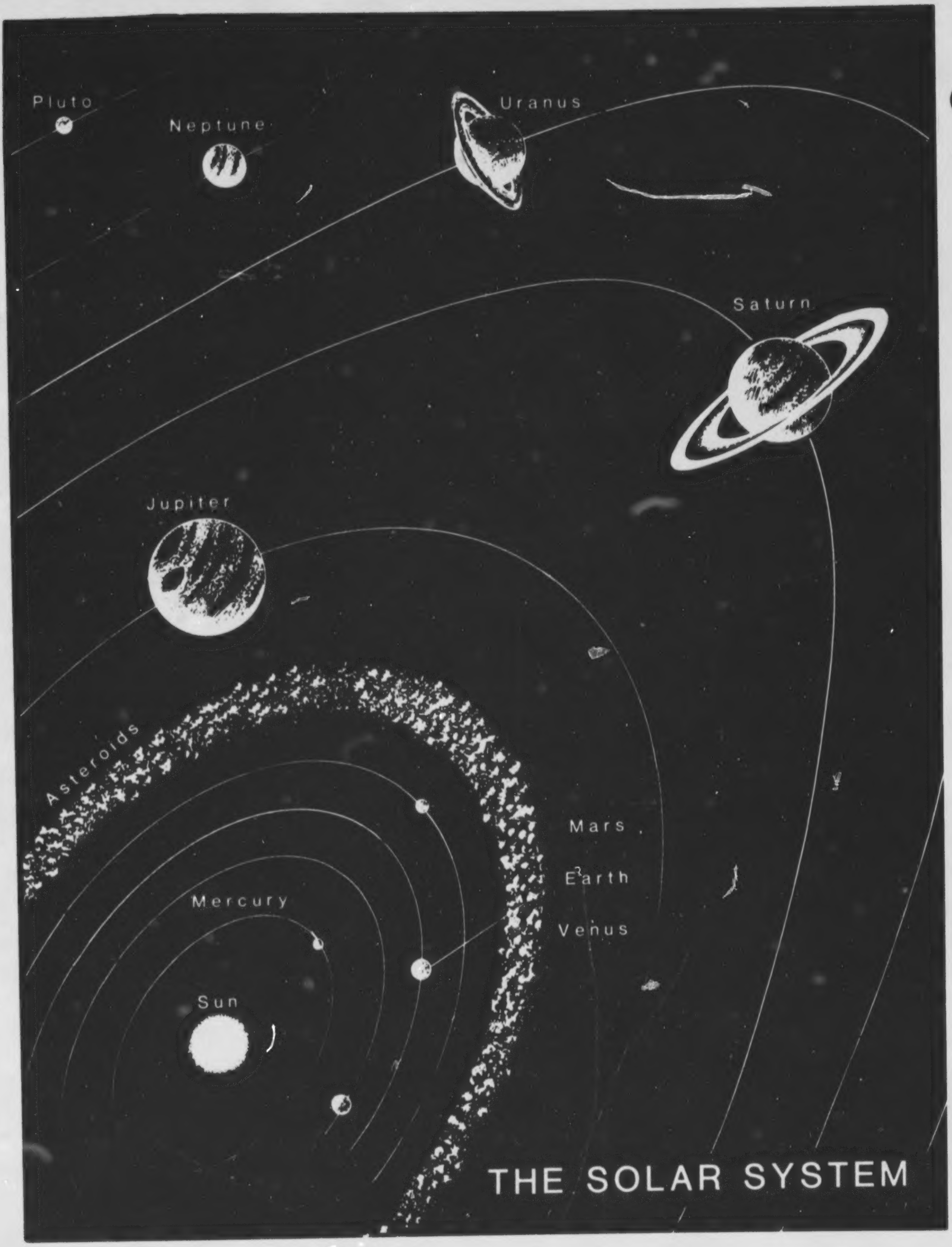


Figure 4-5. The Solar System

belt of asteroids. They pose a mysterious question for astronomers. Are they the remains of a planet that broke apart? Or are they simply material left over from the formation of the solar system?

OUR SUN

** The sun is a giant ball of hot gases with temperatures of up to 15 million degrees at its core. On its surface we can see solar flares, sun spots, and solar prominences. It has strong solar winds which affect the earth. The sun rotates on its axis and spins in the galaxy. Man is looking for ways to get energy from the sun. **

The sun lights and heats the planets, making life on earth possible. The sun is a giant ball of hot gases with a diameter of about 865,000 miles compared to the earth's diameter of about 8,000 miles. It is composed of 80 percent hydrogen and 20 percent helium. We can think of it as a gigantic atomic furnace. Within its core, hydrogen is fused into helium, some 600 million tons per second, at a temperature of 15 million degrees Celsius.

This fusion takes place within the sun's core, an interior layer of dense hot gas. Outside the core is a layer of lighter and cooler gas, from 60 to 2,000 miles thick, known as the photosphere. The photosphere is intensely bright, and it is this layer we normally see when we look at the sun. Astronomers think of it as the surface of the sun. Above it is the sun's atmosphere, composed of the chromosphere and the corona, a halo-like layer visible during solar eclipses.

If we were to view the sun from an orbiting space station such as Skylab, we would see that the sun's surface undergoes violent activity and change. Solar flares, sudden eruptions of very hot gas, appear as bright spots on the surface. We would also see large dark patches called sunspots. These dark patches are actually sites of violent magnetic storms that appear darker than the surrounding surface. Astronomers have accurate records of sunspot activity. They have found that it follows an 11 year cycle. During the cycle the number of sunspots will gradually increase until it reaches a maximum. This cycle is important in predicting possible interruptions to electrical communications on earth. Besides these sunspots, we could see giant streamers of hot gases, called prominences, arching far out into space before they return to the sun's surface.

Not visible to our eyes, but equally important, is the solar wind. The solar wind is a tremendous stream of highly charged particles that the sun sends out constantly. This invisible wind moves far out into space. It interacts with the earth's magnetic field. During periods of high sunspot activity, the solar winds increase in intensity, producing an electrical storm of gigantic size and interfering with radio transmissions on earth.

The sun's apparent motion is closely connected with our sense of time. We are used to timing our day by the sun's movement across the sky. We watch the eastern horizon for the sun's appearance to announce the break of day. We watch the sun slide below the western horizon at the end of the day. When the sun is high overhead we know it is near noon.

A sundial, one of man's earliest clocks, projects the sun's daily movement on a dial marked to show hourly intervals. Most clocks and watches are designed on this same pattern. The hour hand moves around the dial, mimicking the sun's apparent motion around the earth. The hour hand moves twice as fast as the sun, so that it circles the dial twice for each revolution of the earth around the sun. Psychologically, we keep time to the motion of the sun. However, when we go to school and become interested in astronomy, we are shown that the sun is a fixed point of reference, that the earth revolves around the sun, and that it is really the earth's motion around the sun, its rotation on its axis and the tilt of that axis, that account for these time periods; the year, a day, the seasons. Astronomy asks us to shift from an earth-centered point of view which wants to believe that we on earth are the center of the system (i.e., the belief that the sun moves around us) to a change in mental framework that our ancestors experienced during the Copernican revolution (that we rotate around the sun). However, modern astronomy asks us to go beyond even this sun-centered point of view. Astronomers know that the sun has its own motion in relation to our galaxy. The sun rotates on its own axis once every 25 days. And it circles the hub of our galaxy once every 225 million years, carrying the planets along with it.

As we approach the year 2000 we are increasingly aware of our own energy shortage and the sun's abundance of energy. Although astronomers are not directly involved in solving our energy problems, their knowledge of the sun's energy production may help us solve these problems. The sun bombards the earth with a tremendous amount of energy every day. Much of this energy is lost. If we could capture even a small part of that lost energy, we could use it to partially solve our energy problem.

Scientists are currently developing three approaches to capturing this energy. They are (1) developing arrangements of mirrors to collect and focus sunlight, (2) working on solar collectors that are very efficient in absorbing and retaining heat from sunlight, and (3) developing improved solar cells which directly convert sunlight to electrical energy. The byproducts of this research have direct effect on the development of astronomy. Satellites and space probes will be able to operate much longer if they can use sunlight more efficiently to recharge their batteries.

Scientists are also working on a much more ambitious and costly attempt to imitate the process the sun uses to produce energy. Controlled nuclear fusion would produce energy from abundant and low-cost fuel without the buildup of large amounts of dangerous radioactive waste products. There are many technical difficulties because of the tremendous heat and pressure needed to achieve fusion and because of the need to control the reaction. Research is currently underway in both the United States and the Soviet Union. Different approaches are being used. One type is laser-induced fusion. In this approach a very strong focused laser beam briefly strikes a small deuterium-tritium fuel pellet.

The laser pulse heats the pellet to fusion temperatures, and energy is released. In theory it sounds simple, but in practice many difficulties must be overcome before nuclear fusion becomes a reliable and widely-available source of energy. It may be a long time before we can imitate the sun's method of producing energy. In the meantime, we are trying to do a much better job of collecting and using energy from sunlight that is already available to us.

THE PLANETS AND ASTEROID BELT

** The nine planets vary in size, orbit and surface features. All except earth were named after Greek or Roman gods or goddesses. **

1. MERCURY....Mercury was named after the winged messenger of the gods, because it moves around the sun very swiftly, taking only 88 days to complete its orbit. Its orbit is eccentric. At times it approaches as close as 29 million miles to the sun; at other times it is 43 million miles from the sun. It has a diameter of 3,015 miles, making it the smallest of the planets.

Because of its position close to the sun, Mercury is very difficult to observe from earth. The Mariner 10 space probe flew by the planet twice in 1974, giving us our first good view of Mercury's surface. Its surface resembles the surface of our moon. It is pock-marked with basins, ridges, and plains formed by volcanic activity. Mercury has an extremely thin atmosphere of helium. The side of Mercury facing the sun has temperatures as high as 800°F, while on the dark side temperatures fall to -300°F.

2. VENUS....Venus, the second planet, orbits the sun at a distance of 67 million miles. Named after the goddess of love, it has always excited man's imagination as a place where life might exist. These speculations flourished because Venus shines with a bright silvery light, because like earth it has a thick atmosphere, and because close observation of its surface is difficult due to a dense cloud-cover. Venus completes its orbit of the sun once every 255 days. It rotates very slowly on its axis, once every 243 days, the only planet to rotate in a clockwise direction. Its diameter, 7,545 miles, is a little smaller than the diameter of the earth. It is composed mainly of carbon dioxide. The outer layer is a cloud-cover of sulphuric acid with traces of water vapor.

Near the surface of Venus, atmospheric pressure builds to 100 times that of earth and temperatures go as high as 450°C. The USSR Venera space probe gave us the first pictures of the surface of the planet, a rock-strewn plain of sand. These pictures and the data gathered suggest that there is no life on Venus.

3. EARTH AND ITS MOON....Because of its axis of rotation, earth has seasonal changes. Earth has a unique, life-supporting atmosphere. Our own planet and its large satellite occupy an orbit 93 million miles from the sun. Earth has a diameter of 7,000 miles, four times larger than the moon, about the size of Venus and twice the size of Mars. Like the other planets it rotates as it orbits the sun. Its axis of rotation is tilted at an angle of 23° from

its orbital plane. As you know from the chapter on meteorology, this tilt means that the sun's rays reach Earth at a different angle during different times of the year. At the height of summer, 21 June, the North Pole is tilted towards the sun, creating warm weather in the northern hemisphere and cold weather in the southern hemisphere. At the height of winter, 21 December, the situation is reversed; the South Pole is tilted toward the sun.

a. Earth's Features....Besides these seasonal changes, Earth has its unique life-supporting atmosphere, made up of nitrogen and oxygen. The atmosphere also functions as a blanket, retaining and moderating the sun's heat, and filtering out harmful radiation from the sun. The earth's surface is also unique. Two thirds of it is covered with water in a liquid state -- another important life-supporting element. Average temperatures on the surface are remarkably stable and mild, creating an environment in which the other planet's amazing extremes of hot and cold are eliminated and large-scale temperature changes take place over relatively long periods of time.

Most of earth's land masses are covered with vegetation that carries on the key biological process: photosynthesis. Plants capture and use the sun's radiant energy to produce carbohydrates (such as sugar and starch) from carbon dioxide and water. This is the beginning of the long food chain on which we all depend. Through photosynthesis, plants trap enormous amounts of the sun's radiant energy and store it in sugar molecules. The entire organic world runs on this stored energy.

The outer surface of the earth is called its crust. One part of the crust is a layer of heavy basalt, about three miles thick, circling the entire globe. Above the basalt are blocks of granite as much as 40 miles thick. These blocks of granite form the continents. The average thickness of the crust is 20 miles. The crust floats on the mantle, which has a thickness of about 1,000 miles. Beneath the mantle lies the core; an outer core probably of molten iron about 1,400 miles thick and a solid inner core 800 miles thick. Though we speak about the mysteries of outer space, the inner structure of the earth is something of a mystery too. Our information about the inner structure has been obtained mainly from measuring different types of shock waves generated by earthquakes.

Finally, the entire planet is protected by an invisible, magnetic envelope that extends some 40,000 miles into space. This is the earth's magnetosphere. The magnetosphere is oriented to the earth's magnetic poles. It is not symmetrical because the side facing the sun is somewhat flattened by the force of the solar wind. It captures protons and electrons emitted by the sun and confines them.

b. Earth's Moon....The moon is a satellite of the earth with its own motions. The surface of the moon has been mapped and shows craters, mountains, trenches and dark regions called seas. The moon, only 239,000 miles away, has attracted our interest since ancient times. It has also stimulated our first venture into space. Apollo astronauts landed on the moon six times between July 1969 and December 1972. They shared with millions of people the experience of walking about the moon and viewing it close up. They brought back a wealth of photographs, rock, soil samples, direct observations, and recorded data. Rocks taken from the lunar highlands proved to be younger than expected, suggesting that the moon suffered some cataclysmic event after the formation of the solar system. Scientists theorize that a younger layer of rocks suggested that a giant meteorite had built the moon's older, originally formed surface. The interior of the moon proved to be warm rather than cold, as scientists had previously believed. The astronauts discovered local magnetic fields and magnetized rock. They also found a strange orange soil on the rim of one crater. The soil was composed of microscopic bits of orange glass called tektites which scientists believe were produced when the impact of a meteorite created great heat and pressure. The Apollo missions were also an incredible development in the technology of manned space travel. They proved that it was possible for man to travel through space and to return safely to earth. But obviously, the costs of continual moon missions are prohibitive. The advanced telescope must still remain our most practical way of observing the moon's surface. The surface of the moon has been very accurately mapped and all of the major features have been named. Some of these features are:

Craters:	formed by the impact of meteorites, they have high terraced walls, sunken floors and a central mountain group. They may be over 200 miles across and have walls as high as 20,000 feet
Rays:	these are the long white streaks that radiate from many craters. They were probably created by material ejected by meteorite impact
Terrae:	these light-colored highland regions are considered the moon's original crust
Highlands:	much of the surface is covered with mountains that may rise as high as 25,000 feet
Maria:	the name means seas. These dark regions on the surface have a resemblance to seas. Actually they are smooth low-lying regions of more recent origin than terrae
Rilles:	these trenches, sometimes more than 100 miles long, usually occur on the maria. They may be as much as three miles wide and 2,300 feet deep.

Astronomers refer to the near side and the far (or blind) side of the moon. From the earth we see only one side of the moon, the near side. The moon rotates on its axis at exactly the right rate to keep the same side always turned toward the earth. It rotates once on its axis during the time it revolves once around the earth. However, our view of the moon is not monotonous. A different portion of the moon is illuminated by the sun's rays each night. These changes in the illuminated portion are called the moon's phases.

Phase	Day	Change
New	1	Moon is dark; at day 3 or 4 a thin crescent appears that gradually enlarges to a half moon
First Quarter	7	The half moon gradually enlarges until it becomes a full moon
Full Moon	14	Full moon gradually shrinks to a half moon
Last Quarter	21	Half moon gradually becomes a crescent and then darkens completely.

Taking into account the earth's motion around the sun, the moon completes its cycle in about 29 1/2 days and then starts again. The moon's movement through its phases is the clock by which ancient man measured a month. For modern man, using a telescope, the phases provide a constantly changing panorama of the moon's cratered landscape.

4. MARS....Mars, the red planet, is named after the Roman god of war. Its diameter, 4,200 miles, is a little greater than half that of earth. A martian day is about the same as an earth day, but a martian year is almost twice as long. Like the earth, Mars is tilted on its axis so that it has seasonal changes. At a distance of 141 million miles from the sun, Mars has always been a primary location for possible life in space. Two Mariner space probes orbited it in 1969 and 1971. And two Viking landers descended to the surface in 1976. Many people who had hoped that strange Martian creatures might show themselves were disappointed. Even those who hoped for evidence of microorganisms were disappointed. There may still be life on Mars, but if so, it is hidden very well. The surface of Mars plainly shows that it has been cratered by meteorites. It also shows evidence of volcanic activity and weathering by water and wind. Besides the craters, there are smooth regions 50 miles wide. One massive volcano, Nix Oympica, has a base 300 miles wide and rises 20 miles high. Mars has channels but no canals. Some scientists believe that these channels have been cut by water that was melted by the heat of meteorites striking the surface.

5. THE ASTEROID BELT....Between Mars and the next planet, Jupiter, there is a vast space of 342 million miles. Nearly half a million asteroids orbit the sun in this space. They may have a diameter as large as 600 miles, but most are in the range of 60 to 200 miles. Some are spherical but others have an irregular shape. Some scientists explain their existence as the raw material of a planet that did not "jell." Other scientists think that a former planet disintegrated and that the asteroids are the fragments from this break up.

6. JUPITER....Jupiter, the largest planet in the solar system, is more than 11 times as large as earth. It is named after the supreme Roman god. It rotates rapidly on its axis, once every 10 hours; but it takes nearly 12 years to orbit the sun at a distance of 484 million miles. From a distance, Jupiter appears to have alternating light and dark bands. The cause of this banding is not clearly understood. One prominent feature is the Great Red Spot, nearly 25,000 miles long and 9,000 miles wide. The spot seems to be a gigantic and persistent storm.

Jupiter is mainly composed of hydrogen--as a gas in the atmosphere, as a liquid on the planet's surface, and in a liquid-metallic state near the center as high as 30,000 degrees. Jupiter radiates twice as much heat into space as it receives from the sun. It has a strong magnetic field and an extremely powerful magnetosphere. One of Jupiter's 14 moons is larger than the planet Mercury. In some ways Jupiter and its many satellites form a miniature solar system. The space craft Voyager gave us more information about Jupiter than we had gained since Galileo discovered four moons of Jupiter in 1610.

7. SATURN....Famous for its rings, Saturn is the sixth planet in the solar system. It orbits the sun once every 29 years at a distance of 887 million miles. Its diameter is 74,700 miles, smaller than Jupiter but still almost 10 times that of earth. It is named after the ancient Roman god of agriculture. The planet itself has many resemblances to Jupiter in appearance and structure. Scientists have given most of their attention to its remarkable rings (figure 4-6).

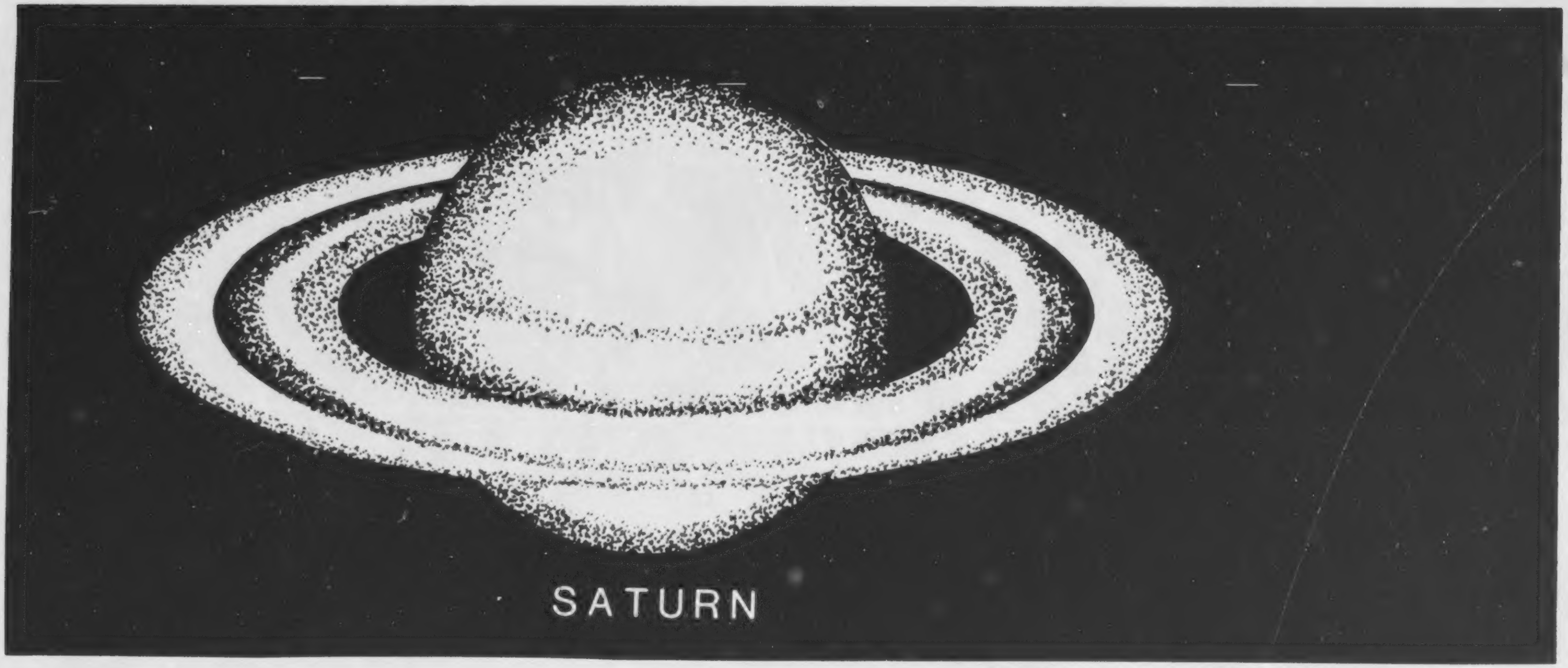


Figure 4-6. Saturn and Its Rings

Since Galileo observed Saturn's rings with his simple 32 power telescope, astronomers have been intrigued by these rings. For many years it was believed that Saturn had three distinct rings somewhat like washers one inside the other. Information transmitted by Voyager I in 1980 on its flyby of Saturn indicates that these are actually many rings and ringlets, described by planetary scientists as being like grooves in a phonograph record. While most of the rings are concentric, some are lopsided, and some even look like they are braided and seem to be interwoven.

In addition to this dazzling view of Saturn's rings, Voyager I also gave astronomers some exciting information about Saturn's moons and discovered a 15th moon. While the Voyager I flyby added tremendous knowledge to what is known about Saturn, some of the new information raised questions called mind boggling by scientists. It left unanswered questions such as: What forms the ringlets? What forces hold them in place? What are the dark radial shapes seen in the images? Why don't two of the moons that have similar orbits collide?

8. THE OUTER PLANETS: URANUS, NEPTUNE, PLUTO....The three remaining planets were discovered almost by accident in relatively recent times. In 1781 the British astronomer Herschel was sweeping the sky with a telescope and found the planet that was later named Uranus. The name is derived from the Greek name for the ancient father of the heavens and ruler of the world. Neptune was discovered as a result of irregularities in the observed orbit of Uranus. The German astronomer Galle is given credit for the discovery in 1846. The name is that of the Roman god of the sea. Pluto was discovered by observing irregularities, this time in the orbit of Neptune. The planet was found in 1930 by Clyde Tombaugh of the Lowell Observatory. It is named after the Roman god of the underworld, perhaps because of the cold and distant orbit of Pluto. It has a very eccentric orbit at an average distance of 3,670 million miles from the sun. Pluto is cold, covered with frozen methane gas, and probably very small, about the size of Mercury. Uranus and Neptune, in contrast, are large with diameters of about 31,000 miles. They all appear to be gaseous, quite cold planets. Temperatures plunge to around -200°C.

COMETS AND METEORS

** Comets and meteors are the fireworks in the sky. Comets revolve around the sun in an eccentric orbit. Meteors are small stone or metal bodies that travel through space. **

Both comets and meteors have attracted attention because they produce unusual "fireworks" in the sky. Comets have a long history by our standards. Halley's comet, the famous comet that appeared in 1834 and 1910 (and marked the birth and death of Mark Twain) has been observed for thousands of years. It appears every 76 years, so it will make another appearance in April 1986. Like other comets, it orbits the sun. Its orbit brings it close to the sun and then far out into space. Only when it approaches the sun closely does it reflect light and attract our attention. It has three parts: head, coma, and tail. The head consists of rocky material held together by frozen gas. The head may have a diameter of as much as 10,000 miles. The coma is the bright fuzzy area around the head. It is made of material from the comet's head; it glows because of stimulation by the solar wind. Finally, the tail consists of particles from the head that glow because of their interaction with the solar wind. The tail always orients itself in a direction away from the sun, sometimes extending for many millions of miles.

Meteors are very small stony or metallic bodies that travel through space. If a planet or moon has no atmosphere to impede them, they fall, impact, and leave craters. Mercury, Mars and the Earth's moon are good examples of planets that have been hit. Meteors approaching Earth usually burn up in our atmosphere with only fiery trails in the sky to prove their existence. However, some have impacted with great force. In Arizona there is a giant meteorite crater, the Barringer, that is over 4,000 feet wide and 500 feet deep. If you look up in the sky at night, you have a good chance of seeing a meteor; five or six occur every hour. We call them falling stars or shooting stars.

This knowledge we now possess is only the beginning of what we will learn about our solar system and the universe. As this book is being completed, Voyager II is about to head for a flyby of Saturn. It will pass Uranus in 1986. Then in 1989 it will reach Neptune, about which we know little. This and future missions will add to our knowledge and be of practical benefit to our lives on this planet. Just as ancient man looked up at the heavens and asked questions, so do we continue to question and to probe for their answers.

VOCABULARY SKILLS:

Define the following words used in the text. Then write an original sentence accurately using each word.

Axis

Satellite

Asteroids

Photosphere

Chromosphere

Corona

Solar flares

Sunspots

Prominences

Solar wind

Magnetic field

Photosynthesis

Phases

Meteor

Meteorite

Eccentric orbit

Craters

Maria

HIDDEN WORD

Fill in the correct word for each clue below. Then arrange the circled letters to make a word in the blanks below.

1. _ _ _ _ _ _ _ _ — Our galaxy is called the _____________.
2. _ _ _ ○ _ _ _ _ _ — Smaller body revolving around a larger body.
3. _ _ _ _ _ ○ _ — Planet closest to the sun.
4. _ _ _ _ — The red planet.
5. _ _ _ ○ _ _ _ — The largest planet.
6. _ _ _ _ _ _ _ _ _ _ _ _ — Masses of cooler gas on the surface of the sun.
7. _ _ _ _ _ _ _ ○ _ _ _ — Stream of highly charged particles radiated by the sun.
8. _ _ _ _ _ _ _ _ _ _ — Tiny planets revolving around the sun in a belt.
9. ○ _ _ _ _ _ — The planet recently shown by Voyager I to have hundreds of separate rings.
10. _ _ _ ○ _ _ — Mass of metal or stone that is heated by friction as it enters the earth's atmosphere.
11. _ _ _ _ _ — A body with a gaseous tail that orbits the sun.
12. ○ _ _ _ _ _ — Seventh planet from the sun.
13. _ _ _ _ _ _ — A system of billions of stars.
14. ○ _ _ _ _ — Shines with a bright silvery light because it has a thick atmosphere.

_ _ _ _ _ _ _ _

FILL IN BLANKS:

Provide a short answer for each of the following questions.

1. The force which holds the planets in orbit around the sun is ____________________.

2. The sun is made up of ____________________.

3. The element found most abundantly in the sun is ____________________.

4. Long streamers called ____________________ explode far out into space from the sun's surface.

5. The large dark patches on the sun's surface called sunspots are actually ________________.

6. Sudden eruptions of very hot gases are called ______________________.

7. The solar wind is directly related to ____________________________.

8. Three approaches to solar energy are: ____________________________
____
____.

9. The area of the sun where hydrogen is fused into helium is __________
____________________.

10. The intensely bright layer of gas outside the core is _______________
________________________.

WORD SEARCH:

Each of the words below is hidden in the puzzle. Find and circle them. Words may be forwards, backwards, vertical, horizontal or diagonal.

L	G	C	E	S	A	T	E	L	L	I	T	E	S	O	P
D	A	N	N	P	O	R	S	L	I	M	A	R	Z	T	Q
L	C	B	M	E	N	E	P	M	E	R	C	U	R	Y	T
N	E	P	T	O	A	N	A	P	L	N	G	Q	R	I	L
J	U	P	I	T	E	R	S	H	M	E	T	E	O	R	S
A	W	T	H	E	S	A	T	E	A	N	I	T	M	A	I
Q	N	W	X	D	K	N	E	H	S	E	V	R	C	S	G
S	Q	D	R	I	R	G	R	T	T	V	E	N	U	S	D
T	S	M	E	X	K	E	O	T	E	W	I	Y	L	U	N
O	U	O	N	L	L	S	I	I	M	H	N	W	I	N	I
G	N	T	S	Z	B	S	D	C	O	O	G	I	T	A	W
H	S	R	L	A	G	B	S	E	C	N	I	M	O	R	R
I	P	V	Y	B	T	E	P	L	T	W	N	L	T	U	A
M	O	N	E	P	T	U	N	E	I	D	D	L	H	C	L
N	T	U	L	Q	U	U	R	B	O	O	U	I	O	C	O
H	S	C	Z	R	O	E	A	N	N	G	S	A	M	R	S
L	N	G	N	S	R	I	G	R	P	L	U	T	O	A	B

SATELLITES
MERCURY
EARTH
MARS
JUPITER
SUNSPOTS
SOLAR WIND
ASTEROIDS

SATURN
METEORS
COMETS
NEPTUNE
URANUS
PLUTO
VENUS

HIDDEN MESSAGE

Fill in the correct word for each clue below. Then place the numbered letters in the correct blanks on the numbered message lines.

_ _ 5 1 _ _ _ 7 26 _ 3 _ _ 19	The process by which plants use the sun's energy to produce food.
_ 2 20 _ 22 _	Apparent changes in the shape of the moon.
_ _ 14 _ 13 _ _	Depressions in the moon's surface caused by meteorites.
4 _ _ _ _ 10 6 _ _ _ _ _ _	Magnetic field of the earth.
_ 25 _ 23 _ 9	Deep trenches on the moon's surface.
11 _ _ _ 24 _ _ _ 18	Mountainous areas of the moon.
1 8 _ _	The earth's _____ is 23°.
_ _ 21 12 15	An important life-supporting element that covers much of the earth's surface.
14 16 _ _ _ _ 17 27 _ _ _	Layers of air surrounding the earth.

1 2 3   4 5 6 7   8 9   10 11 12   13 14 15 16 17 18

19 20 21 22 23 24 25 26 27

MATCHING:

Match the words in column I with the phrases in column II by placing the correct letters in the blanks.

I	II
_____ 1. Chromosphere	A. Outer layer of the sun's atmosphere.
_____ 2. Orbit	B. Occur in 11 year cycles.
_____ 3. Solar Wind	C. An object held in orbit by gravity.
_____ 4. Photosphere	D. A circular path.
_____ 5. Rotation	E. An invisible magnetic envelope which surrounds earth.
_____ 6. Sundial	F. Lower layer of sun's atmosphere.
_____ 7. Gravity	G. Spinning on an axis.
_____ 8. Satellite	H. A force that pulls toward the center of the earth.
_____ 9. Photosynthesis	I. One of man's earliest clocks.
_____ 10. Sun Spots	J. Gives off most of sun's light.
_____ 11. Magnetosphere	K. Process by which plants use sunlight to produce food.
_____ 12. Corona	L. Stream of highly charged particles from the sun.

NAME THE PLANET DESCRIBED:

1. It has icy caps at its poles ______________
2. Closest to the sun ______________
3. Next orbit past earth ______________
4. Rings around it ______________
5. Largest of the planets ______________
6. Very bright and silvery ______________
7. Day almost like earth's day ______________
8. Red color ______________
9. No satellites ______________, ______________, ______________
10. Planet with greatest number of satellites ______________

Match the planets on the right with the name of the gods or goddesses on left. Put the correct letter in the blank.

a. The winged messenger of the gods.
b. Roman god of the underworld.
c. The goddess of love.
d. Ancient father of the heavens and ruler of the world.
e. Roman god of the sea.
f. Ancient Roman god of agriculture.
g. The supreme Roman god.
h. Roman god of war.
i. Only planet not named after a god or goddess.

1. Jupiter ______
2. Uranus ______
3. Pluto ______
4. Neptune ______
5. Earth ______
6. Saturn ______
7. Venus ______
8. Mercury ______
9. Mars ______

Data Chart (p. 308)

Use the text and other reference books to gather data for the chart. Fill in as much information as possible.

Planet	Diameter	Distance from Sun in miles	Number of Satellites	Rotation Time	Number of days to Orbit Sun	Name of Space Mission (if any)	Special Characteristics
Mercury							
Venus							
Earth							
Mars							
Jupiter							
Saturn							
Uranus							
Neptune							
Pluto							

Now use the chart's data to identify the missing planet.

1. ____________ Planet that orbits the sun in 365.26 days.

2. ____________ Only planet that rotates in a counterclockwise direction.

3. ____________ Planet with great red spot.

4. ____________ Planet with many rings.

5. ____________ Planet with same diameter as Uranus.

6. ____________ Planets with eccentric orbits.

BRAIN TEASERS:

1. Science fiction writers often invent life forms from fictional worlds. These forms are best when they are believable. For example, a nitrogen-breathing creature would not be believable if invented in earth's atmosphere. Dr. Spock on Star Trek is a good example of a character who is believable because of his direct relationship with a home planet.

Make up an imaginary life form appropriate for one or more of the nine planets in our own solar system. Imagine the form closely connected to what you know about the planet's atmosphere, temperature, size, magnetic fields, physical structure, etc. Describe the form to the class.

2. Discuss what you see as the differences between believing (as did ancient man) that the earth is the center of the universe and the modern understanding that the sun is the center of our solar system. Specifically, what changes in man's idea of himself came about as a result of this change in focus.

3. What is the difference between telling time by looking at a clock and telling time only by observing the sun? Consider for example, the actual physical divisions on the face of a clock (hour, minute, and second hands) and lack of these physical divisions in the sky.

4. Write or visit Disney World's Solar Energy Project in Orlando, Florida, to determine some of the recent developments in solar energy research. Discuss with the class what you feel are the most promising developments.

5. Visit the library and see if you can locate books or articles on solar collectors. See if you can actually build a simple model.

6. Divide the class into three committees representing three groups of scientists. Then research each major hypothesis concerning the origin of our solar system: encounter hypothesis, nebular hypothesis, protoplanet hypothesis. Then, as scientists, debate the merits of each theory.

7. Continue to research the new information discovered from Voyager I mission. Summarize your findings as a TV news bulletin.

8. Go to the library and get the tape of Orson Wells' broadcast of H. G. Welles' War of the Worlds. Listen to it and, then, knowing what you do about Mars, discuss (a) how scientifically plausible the story is, (b) why the story seemed so convincing to listening audiences.

CHAPTER V: ELECTRICITY AND ELECTRONICS

** Electrical and electronic equipment increase our ability to see, to hear, and to communicate. **

In earlier times the success or failure of a ship's voyage depended on the eyes and ears of the crew. This is still true today. However, ships must operate at night and in bad weather. We must be able to find objects or targets under the sea. It is obvious that our eyes, ears and voices limit our ability to do these things. We need something that will aid or increase our capability to see, to hear, and to communicate. Electrical and electronic equipment give us this capability. Radio, radar and sonar are as common to our modern ships as sails were in the past. It is important then to understand how this equipment works.

ELECTRICAL ENERGY

** Electrical energy is the result of moving electrons out of their circular paths around the atom so that they may move freely in another material. **

Energy is very important in our lives. Recently we have become very much aware of energy. There are many forms of energy. For example, wheels turning on our car is called mechanical energy; the warmth from a fire is called heat energy; the light that brightens a room is called light energy. One form of energy can be changed to another form of energy. The heat energy in a car engine turns the wheels of a car; thus heat energy is changed to mechanical energy. The electrical energy in our home can be changed to heat energy. This happens when we use an electric stove or oven. We can relate energy to movement. For instance, heat energy is the result of molecular movement. (Molecules are the smallest particles of a substance.) Mechanical energy is the result of moving objects such as the turning of a wheel; the lifting of an object by use of a lever or fulcrum. If energy comes from moving objects then what is electrical energy?

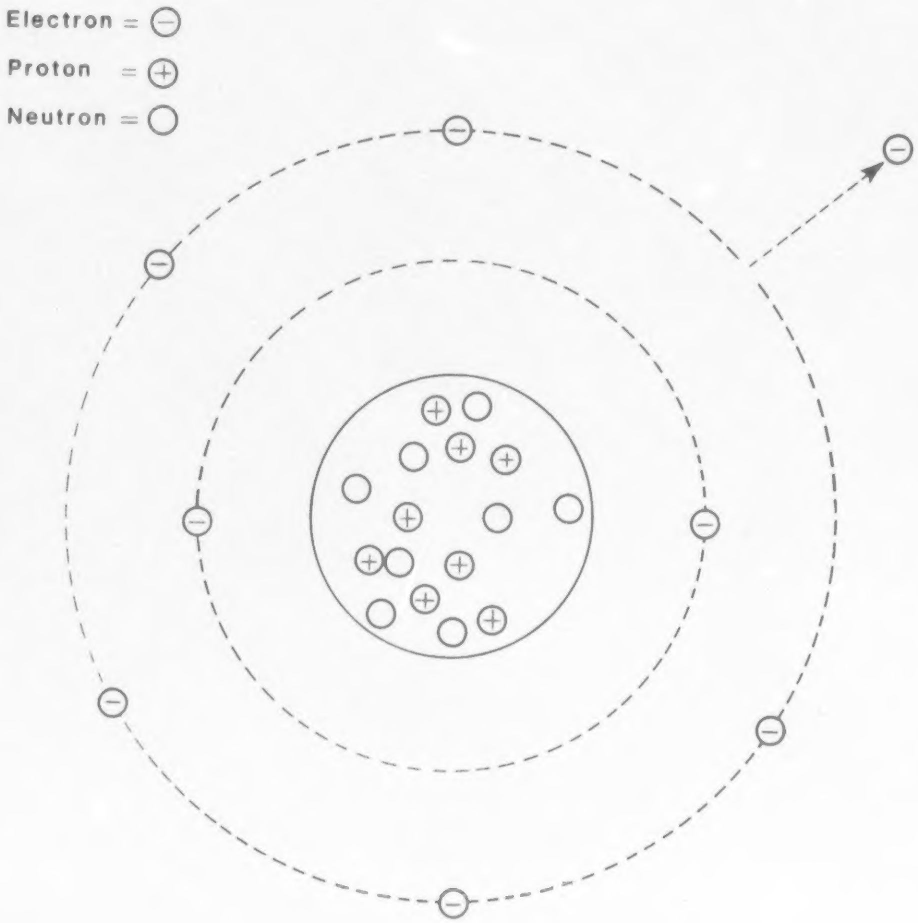
Electrical energy was first discovered by the ancient Greeks. They found that by rubbing a mineral called amber with a cloth (mechanical energy), they could create a mysterious force of attraction between the cloth and the amber. They also saw that after they rubbed two different ambers with two different cloths, the cloths would repel one another -- as strongly as they were attracted to the amber. They called this mysterious force of attraction "elektron" meaning "amber." The ancient Greeks had changed mechanical energy (rubbing together of cloth and amber) to electrical energy.

The actual nature of electrical energy was not explained until the atomic theory of matter was developed. The atomic theory of matter gave us an explanation of what objects were moving to create electrical energy. The atom is the smallest part of an element. Atoms are smaller than molecules. Several elements may combine to form a substance. An atom can best be pictured as a very small solar system. The center of the atom is called the nucleus and can be pictured as the sun in our solar system. The center of the atom contains two major particles called protons and neutrons. Circling the nucleus, just as the planets revolve around the sun, are particles called electrons. The protons in the center of the atom have small positive electrical charges; the electrons circling the nucleus of the atom have small negative electrical charges. Neutrons have no electrical charges. The electrons stay in their circular paths around the center of the atom because their negative electrical charges are attracted to the positive electrically charged protons. It is much the same as planets are held in their circular paths by the gravitational force between the planets and the sun. When the ancient Greeks rubbed the amber with a cloth they were rubbing the electrons from the outer orbits of the amber atoms and collecting them on the cloth. The cloth then has a number of electrons called free electrons that normally it would not have. Due to the transfer of electrons from the amber to the cloth, the amber now has fewer electrons than before. The negative charges of the electrons on the cloth now give off a negative overall charge to the cloth while the reduction of the electrons in the amber give an overall positive charge to the amber. The reason the charged cloth would repel another charged cloth illustrates a simple concept; that is, like charges repel while unlike charges attract each other. Electrical energy, then, is the result of moving electrons out of their circular paths around the atom so they may move freely in another material. The movement of these free electrons can be controlled using electrically charged materials. Positively charged material will attract them; negatively charged material will repel them.

Figure 5-1 shows an electron being dislodged from its orbital path. This buildup of positive and negative electrical charges is familiar to all of us. We have often been shocked after walking on a carpet and touching a metal door knob. The same experience results from sliding across a car seat and touching the door handle. We have often referred to this as "static electricity."

The electrical energy used in our appliances, lights, radios, and television is called "current electricity." Current electricity is different than static electricity because the free electrons continue to flow over longer periods of time. As you will recall, being shocked with static electricity was painful but very fast. The electrons quickly flowed back to the places they were dislodged from and the electrical force disappeared. Current electricity keeps a steady flow of electrons from a negative source to a positive source over long periods of time. In the case of static electricity the shock is soon over; however, in the case of current electricity (such as from a wall plug) the shock continues until you remove yourself from the plug.

We have seen that electrical energy is the buildup of electrons and the movement of these electrons. We need to understand that we can start, change or stop this flow of electrons or electrical current. We know that movement of objects can be started, changed, directed or stopped simply by changing the material through which they travel. For example, let us consider our own movement. We can move quickly through an open room. Of course, we move less easily and are sometimes stopped in a very crowded room. Electrons act in much the same way; they move easily through some materials, with difficulty through some materials, and not at all in other materials. Materials that electrons move easily through are called conductors. Good conductors are materials such as copper, silver and gold. Materials that do not permit electrons to flow are called insulators. Good insulators are materials such as wood and rubber. The basis for electrical devices is to control or direct electron flow. It may be in the form of a simple light switch. Here we simply break the path of current flow and the light goes out, or we complete the conductor path



THE STRUCTURE OF AN ATOM WITH ONE ELECTRON BEING DISLODGED FROM ORBITAL PATH

Figure 5-1. The Structure of an Atom

between the light and the electrical energy and the light comes on. The complex electrical circuits (a circuit is a path for current flow) in a radio or radar very precisely control the current flow through the equipment. These circuits also change electrical energy into other forms of energy such as heat from an oven, light from a bulb or television screen, or sound from a radio.

ELECTROMAGNETIC WAVES

** An electromagnetic wave occurs when electrical energy is changed to magnetic energy and the magnetic energy is changed back to electrical energy. **

The electrical energy we have discussed so far has been static electricity and current electricity. We have seen how electrical energy can be produced by building up a source of free electrons. The movement of these electrons through a conductor produce electrical energy we can use. We know, however, that radios do not require conductors between the transmitter and receiver. How then is this electrical energy transmitted across space? The answer to this question is: through electromagnetic waves. Of course the next question is: What is an electromagnetic wave? Simply by its name, electromagnetic, we are led to believe the wave consists of electricity (electro) and magnetism (magnetic). We are right in this belief because the electromagnetic wave does consist of electrical and magnetic energy. Scientists, while studying electricity, found that magnetic energy is closely associated with electrical energy. For instance, if we created current flow through a conductor in a wall, we could turn the circuit on and move a compass around the area of the conductor. The closer we place the compass to the conductor, the more the compass needle would align itself across the wire. The reason for this is as current flows through the wire it creates a magnetic field around the wire.

The more electron or current flow, the stronger the magnetic field. Picture then a stick shoved into some sand. As we shove the stick into the sand, the sand ripples out away from the stick. As we remove the stick from the sand, the sand will close in around the stick and fill the hole. In an electrical conductor, as we build up more and more current, we build up a larger magnetic force; as we reduce current, this magnetic field collapses or gets smaller. Making an electromagnetic wave depends on this relationship of electrical and magnetic energy. In a radio antenna, which is actually a conductor, a strong electrical current is generated. This produces a strong magnetic field around the antenna. Now we reduce the current flow and the magnetic energy begins to collapse. At the ends of the antenna, this collapsing of the magnetic energy is changed to electrical energy. Once this magnetic energy has been changed to electrical energy, the electrical energy begins to grow smaller. As this happens the electrical energy is changed back to magnetic energy and we begin the process again. Thus, an electromagnetic wave is produced when electrical energy is changed to magnetic energy and the magnetic energy is changed back to electrical energy.

Now that we understand that electromagnetic waves consist of electrical and magnetic energy, we will continue our discussion of electromagnetic waves but will focus on the electrical energy portion. This will make it a little easier to understand. Electromagnetic waves have the following four important characteristics (figure 5-2):

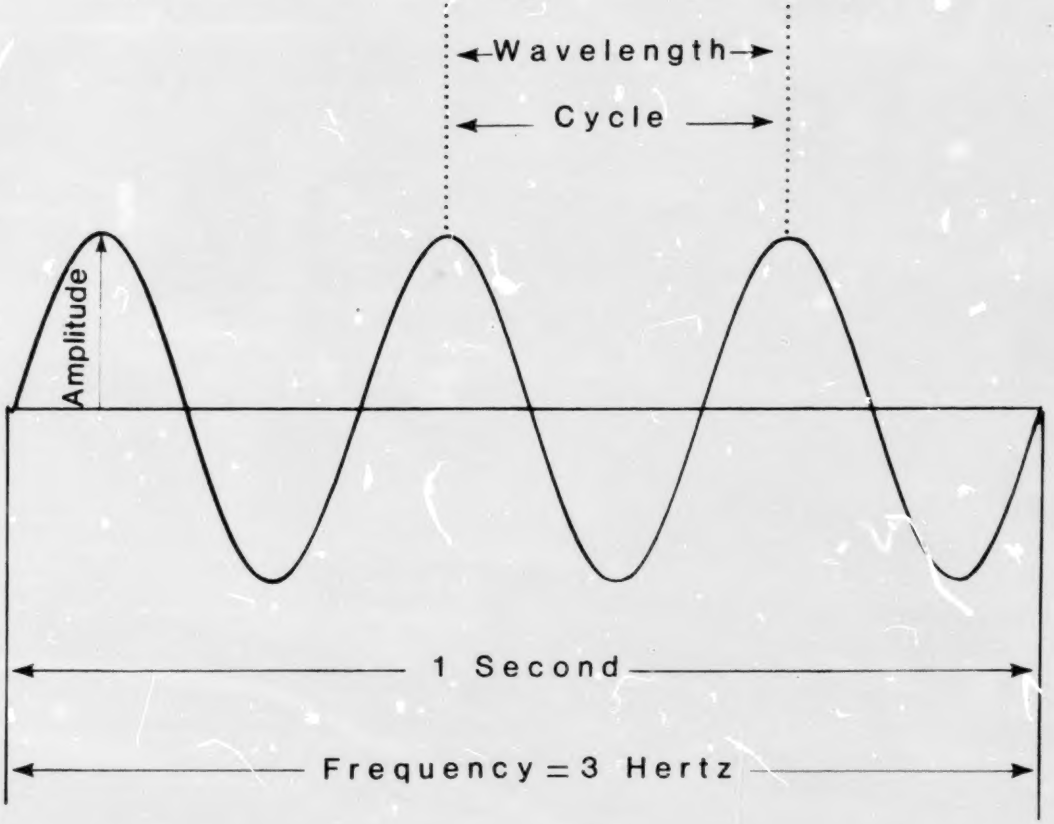
1. Amplitude....The amplitude is a measure of the size or energy level of the wave.

2. Cycle....A wave cycle may be considered as one wave. The bigger the wave the more energy it has. It is shown in figure 5-2 as going from the top or crest of one wave to the top or crest of the next wave. From our earlier discussion it would be from the point at which the electrical energy was the greatest, through the point it was the smallest and back to the greatest point.

3. Wavelength....A wavelength is the space occupied by one cycle and is usually measured in meters.

4. Frequency....Frequency is the number of cycles that occur during a specific time, usually one second. Frequency is measured in Hertz. Thus, 1 hertz = 1 cycle per second. "Hertz" is abbreviated as Hz.

Electromagnetic waves may have many different frequencies and wavelengths have different characteristics. For instance, the visible lights we see are really electromagnetic waves. The different colors we see are really different wavelengths of electromagnetic waves. X-rays are shorter wavelengths of electromagnetic waves than visible light. We cannot see X-rays but we can use



CHARACTERISTICS OF A RADIO WAVE, WITH A FREQUENCY OF 3 HERTZ.

Figure 5-2. Characteristics of a Radio Wave

photographic film to aid us in seeing their effects. Anyone that has had a broken bone and an X-ray picture can see that X-rays go through matter much easier than visible light. Just as with X-rays, we cannot see radio waves. We need electronic equipment to detect radio waves just as we need photographic film to detect X-rays. Radio waves, light waves, and X-rays have one thing in common; they travel at the speed of light or 186,000 miles per second.

We have discussed how radio waves or electromagnetic waves are made. These waves travel outward from the antenna in generally straight paths. If a conductor or receiving antenna is put in the path of these radio waves, a small electrical current will be generated in the antenna. Recall that we used a large electric current to produce a radio wave; now at the receiver the opposite happens, i.e., we get a small current from the electromagnetic wave. By amplifying or making this current larger in the radio receiver we can detect the radio wave signal. It is important that the frequency of the radio receiver is tuned or set at the same frequency as the radio transmitter. The range or distance between the radio transmitter and receiver may be extended because of the effect of the earth and atmosphere on radio waves. Low frequency radio waves bend over the horizon rather than follow absolute straight paths. This bending of radio waves is called refraction and diffraction. The radio wave may also be "bounced off" or reflected from the part of our atmosphere called the ionosphere. Figure 5-3 shows the bending of radio waves by the earth (diffraction) and atmosphere (refraction).

The effects of refraction or reflection are very noticeable at night. You may have noticed your radio receives stations from far away during evening and night. This is mainly because refraction and reflection extend the range of transmitted radio waves. The benefit of radio waves for giving us fast and good communication is obvious. Radio waves also give us excellent navigation aids for determining our location. All we need to do is determine the direction our received radio signal is coming from. By determining the exact directions from two or more radio transmitters we can pinpoint our exact location.

RADAR

One device that has been used widely for navigation and for detecting and ranging on targets is radar (short for radio detecting and ranging). Figure 5-4 shows radar

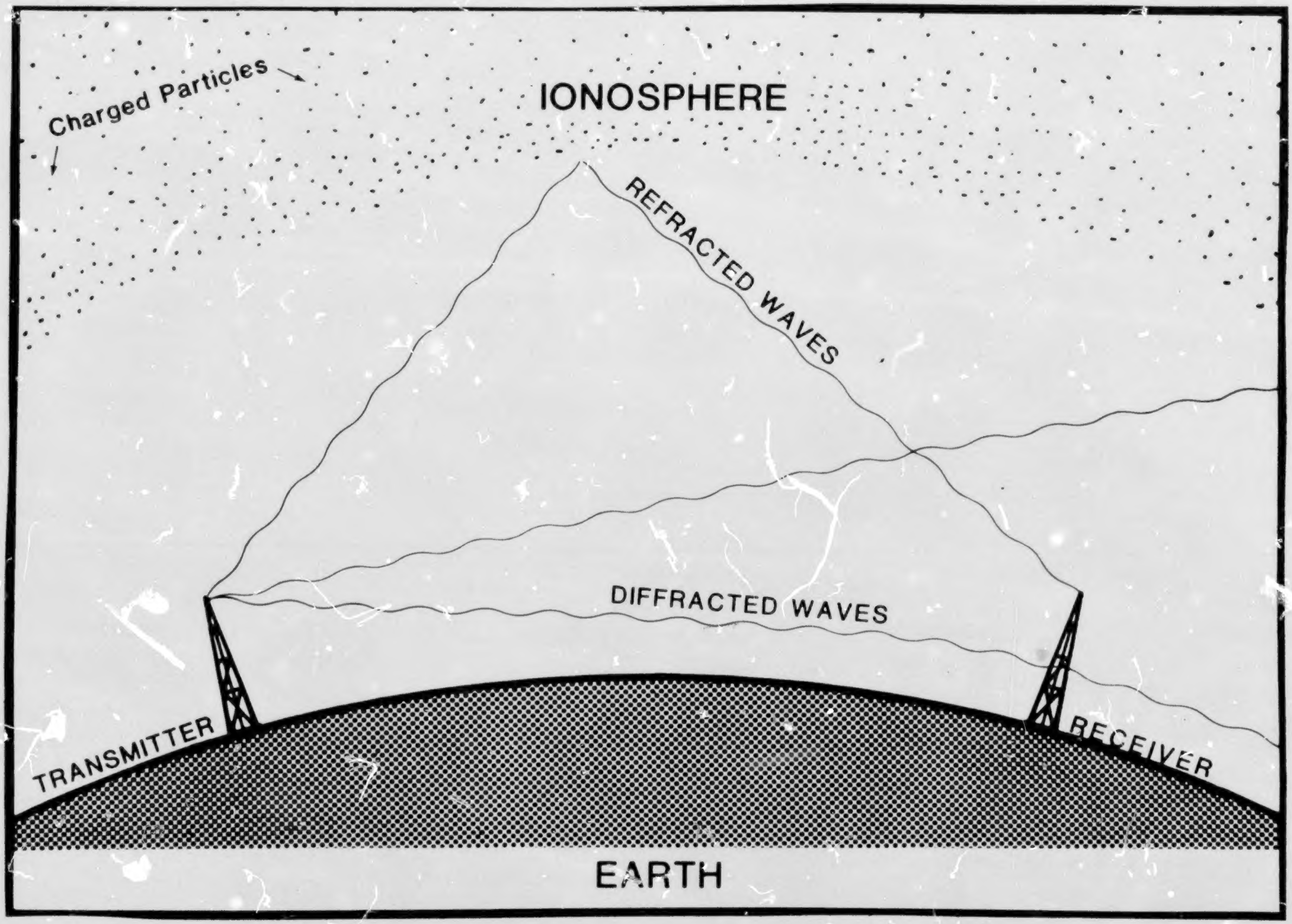


Figure 5-3. The Bending of Radio Waves by the Earth's Atmosphere

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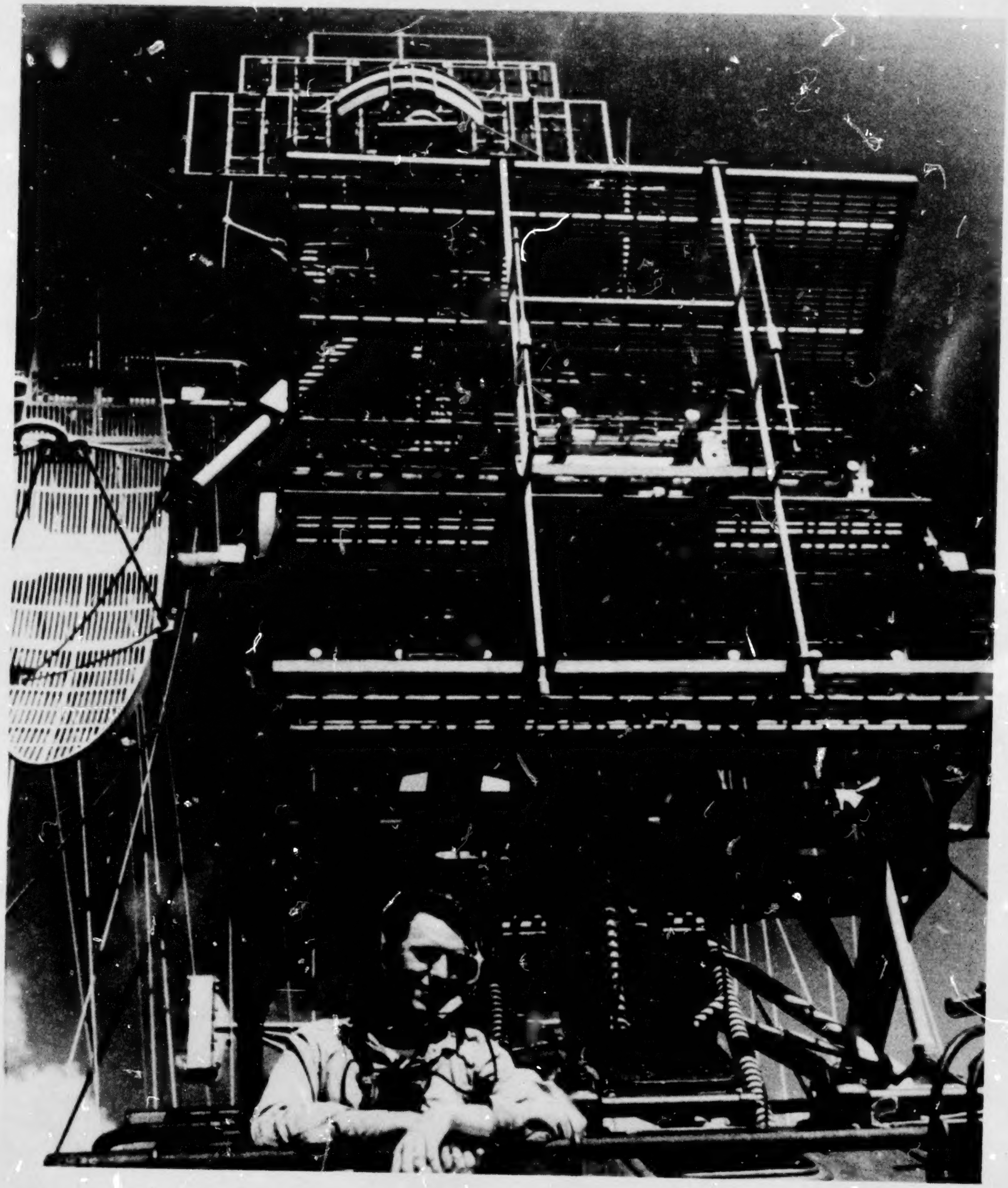


Figure 5-4. Radar Equipment on a Ship

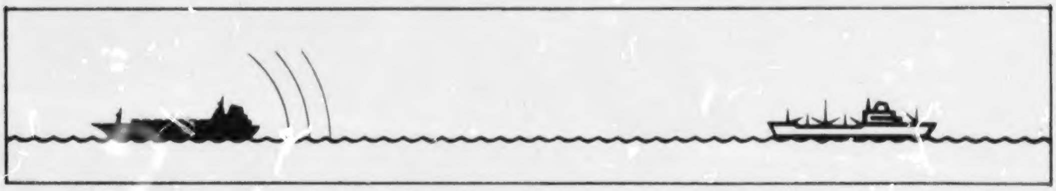
equipment aboard ship. Radar uses two important principles we learned about in electromagnetic waves, these waves travel at a constant speed of 186,000 miles per second and they travel in straight paths. If we were to generate a powerful burst or pulse of electromagnetic waves, it would travel in a straight line outward at 186,000 miles per second. If the pulse struck an object, some of the electromagnetic energy would be bounced back toward the antenna. This reflected energy would also travel at 186,000 miles per second. By receiving this reflection we would know the direction (the original direction of the transmitted pulse) to the object. We could also determine the range or distance to the object by knowing the time between the transmitted pulse and the received reflection. For example, suppose we sent a pulse of electromagnetic energy straight in front of us toward an object 186,000 miles away. We know the pulse will strike the object in one second and part of the pulse will be bounced back toward us. One second later the reflected pulse will be received at our antenna. We know the direction we sent the pulse (straight ahead); therefore, we know upon receiving a reflected pulse an object is directly in front of us. We know the time we sent the pulse and the time we received the reflected return pulse (two seconds). We know the transmitted pulse traveled at 186,000 miles per second to the object and the returned reflection traveled at 186,000 miles per second back to our antenna. The total time then between transmitted pulse and returned pulse is 2 seconds. We can then determine an object is directly in front of us 186,000 miles away.

Of course, radar normally operates on much shorter distances than this. The time between transmitted and received pulses will be in fractions of a second. However, the same principle applies for short ranges. Typically the antenna will rotate or change directions effectively "searching" the area for objects. Figure 5-5 illustrates the principle of radar operation.

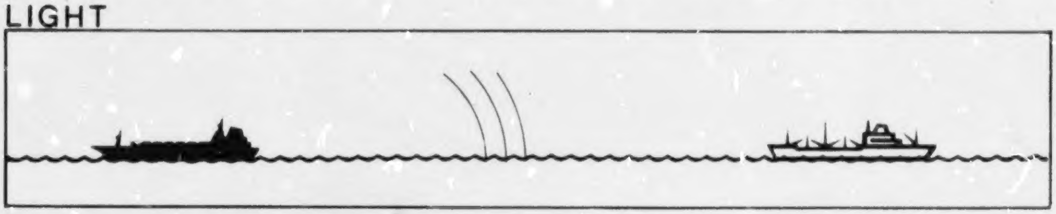
SOUND WAVES AND SONAR

** A sound wave is simply areas of high pressure and low pressure in the material through which sound travels. **

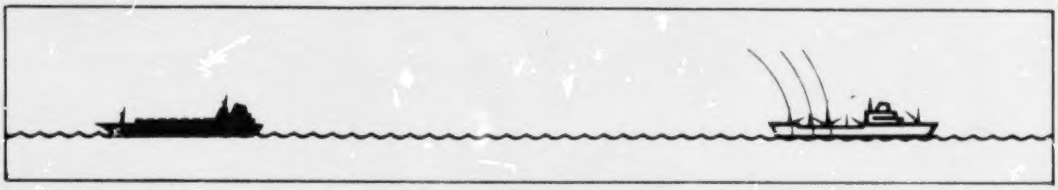
In addition to detecting and determining the distance of surface objects or targets, we also must detect and range objects or targets beneath the surface of the sea. While radar is excellent for the first purpose, it is not very useful for detecting objects or targets in the water.



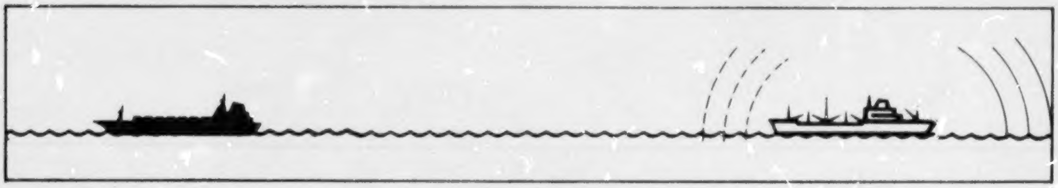
PULSE LEAVES RADAR ANTENNA AT THE SPEED OF LIGHT



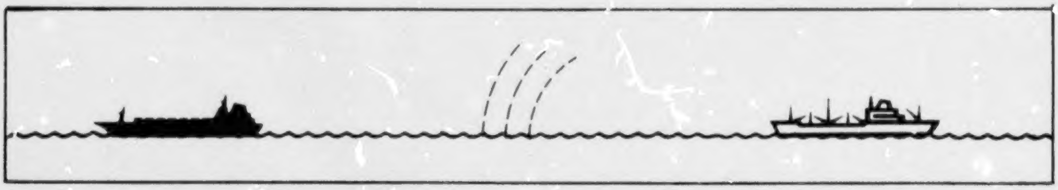
PULSE CONTINUES THROUGH SPACE



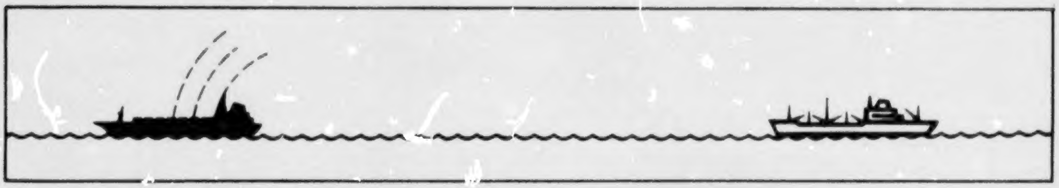
PULSE STRIKES TARGET



ECHO IS RETURNED AS ORIGINAL PULSE CONTINUES



ECHO RETURNING AT SPEED OF LIGHT



ECHO RECEIVED BY ANTENNA GIVING INDICATION ON SCOPE OF PRESENCE OF OTHER SHIP.

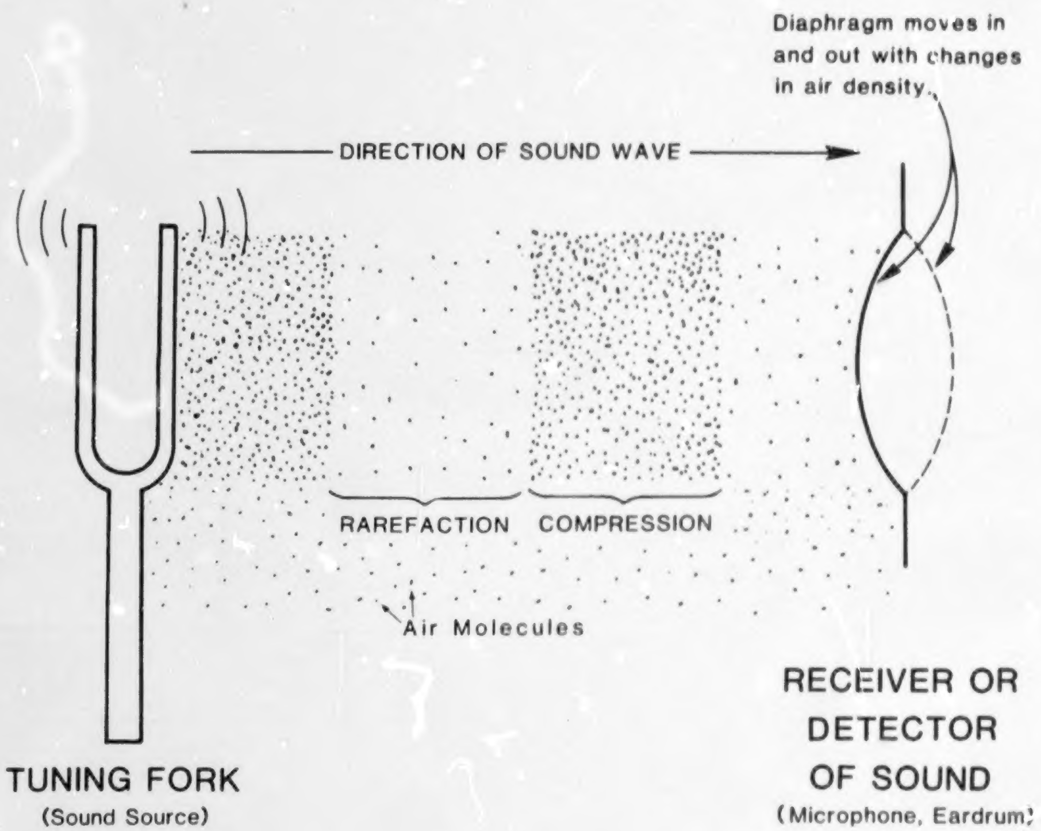
Figure 5-5. The Principle of Radar Operation

To aid us in detecting and locating objects in the water we rely on sonar (short for sound navigation and ranging). While sonar is built using electrical circuits, it does not use electrical energy or electromagnetic waves to detect targets as radar does. Instead sonar makes use of sound waves. It is very important that we know the difference between sound waves and electromagnetic waves. About the only thing that sound waves have in common with electromagnetic waves is that they are both waves. Nevertheless, the principles of radar and sonar operations are very similar. However, before we compare the systems, let us first look briefly at the nature of sound, sound waves and how they differ from electromagnetic waves.

We need three things to produce sound:

1. We must have a sound source
2. We must have a material through which the sound can travel also called a medium
3. We need a receiver or a detector for the sound.

If any of these three needed items are missing we have no sound. We have often asked, If a tree fell in the woods and no one heard it fall, would there be a sound? The answer is obvious from our requirements for sound. Without a receiver or detector, there is no perceived sound. With this puzzle laid to rest, let us examine the nature of sound as shown in figure 5-6. We have a sound source (in this case a tuning fork), a medium (air) and a receiver or sound detector (microphone or eardrum). The sound source changes the movement of the tuning fork (mechanical energy) into changes in pressure of the medium (sound energy). As the tuning fork moves in one direction, it shoves or compresses the air molecules. This compression makes the air molecules more dense in the area of compression. As the tuning fork moves in the opposite direction, it pulls the air molecules out of an area. The region of fewer air molecules is called a rarefraction. The vibration of the tuning fork results in areas where air molecules are very thick or dense (compression) and areas where the air molecules are very thin (rarefraction). The series of compressions and rarefractions result in sound waves. A sound wave then is simply areas of high pressure and low pressure in the transmitting material or medium. As this changing pressure strikes a receiver or sound detector, it is set in motion.



Vibrations from the tuning fork causes density changes in the surrounding air molecules. These changes are called COMPRESSION (higher density) and RAREFACTION (lower density). These regions of different densities and pressure cause the receiver to vibrate or be set in motion.

Figure 5-6. Receiver or Detector of Sound

This is very much like a tree bending and straightening in a gusty wind.

The sound wave has generally the same four characteristics as the electromagnetic wave. It has amplitude. In the case of a sound wave we are referring to the amount of pressure changes in the medium. It has a cycle, which would be the point of most pressure in the medium, through the point of least pressure, to the point of highest pressure. A cycle will contain one compression and one rarefraction. Frequency is the number of cycles in a specified time, usually one second. Frequency of sound is expressed in cycles per second. Wavelength is the space occupied by one cycle and is usually measured in meters. Wavelength of sound is not commonly used to describe a sound wave. As we have discussed before, sound waves require a material to travel in, much as electrical current requires a conductor. The speed the sound waves travel depends on the type of material. For example, sound will travel about 4 times faster in water than in air; through steel it is about 15 times faster than through air. This is very much different than electromagnetic waves that travel at a constant speed and do not require a material to travel in. Not only does the material or medium affect the speed at which a sound wave travels, but conditions of the medium also affect the speed. For instance, sound will travel faster in warm water than in cold water; it will travel faster in salt water than in fresh water; and it will travel faster at greater depths in the water because of increasing pressure. Sound waves also tend to lose energy very quickly due to the molecules in the medium absorbing some of the energy. Sound waves will be bent much more easily than electromagnetic waves. They will tend to bend toward areas in which they travel faster or easier. Since temperature, salt or salinity, and pressure combine to change speed of sound waves in water, these waves will not travel in a straight path. This bending is called refraction just as in electromagnetic waves. Sound waves may be reflected or bounced off an object just as electromagnetic waves are reflected. You may have noticed this as an echo of your voice when you shouted toward an object or blew a car horn inside a tunnel.

In summary then, sound waves travel at much lower speeds than electromagnetic waves. Sound waves travel at different speeds in different material under different conditions while the speed of electromagnetic waves is constant. Sound waves are more apt to bend or refract than electromagnetic waves and may not travel in generally straight paths. Sound waves can be reflected just as electromagnetic waves can be. This gives us the ability to use sonar principles in much the same way as radar.

There are two types of sonar; passive and active. Passive sonar acts much like a radio receiver. We simply put a sound detector or receiver in the water and listen for underwater noises. Active sonar uses the same principle as radar. We generate a sound pulse in the water and listen for returned or reflected pulses (echos). The direction of the returned pulse and the amount of time between transmission and reception of the pulse may be used to find direction and range. Because the speed of sound and the direction of sound may change, accurate locations of objects are difficult to determine. A sonar operator must have a great deal of training and experience to accurately locate objects or targets.

SUMMARY

Electricity and electronics have given us the ability to extend our eyes and ears. This is necessary in our modern Navy because we must operate around the clock in periods of darkness and bad weather. Radio has extended our ability to communicate and navigate. Radar and sonar have provided us with a means to identify and locate targets. We need to understand the operation of these devices if we are to use them effectively.

MULTIPLE CHOICE QUESTIONS:

1. Electrical and electronic equipment:
   - a. are very special types of equipment that are not commonly used.
   - b. extend our capability to see, to hear, and to communicate.
   - c. are used to change heat energy to mechanical energy.
   - d. use static electricity for power.

2. Electrical energy is the result of:
   - a. protons attracting other protons.
   - b. electrons attracting other electrons.
   - c. free movement of electrons.
   - d. electrons moving in circular orbits around the atom's nucleus.

3. The smallest part of an element is a/an:
   - a. atom.
   - b. molecule.
   - c. proton.
   - d. substance.

4. The nature of electrical energy was explained by:
   - a. the ancient Greeks.
   - b. the discovery of the solar system.
   - c. gravitation forces between the sun and planets.
   - d. development of the atomic theory of matter.

5. Current electricity is used to:
   - a. build up a charge in amber and cloth by rubbing them together.
   - b. create an electrical shock for people walking on a carpet or sliding across a car seat.
   - c. quickly discharge electrical energy.
   - d. provide energy to appliances.

6. Materials that electrons travel in easily are:
   - a. silver.
   - b. copper.
   - c. gold.
   - d. All of the above.

7. The general purpose of electrical circuits and devices is to:
   - a. control and direct electron flow.
   - b. provide mechanical energy.
   - c. provide communications.
   - d. control the amount of heat energy in appliances, lights, radios, and television.

8. Electrical energy can be transmitted:

   a. through wires.
   b. through conductors.
   c. across space.
   d. all of the above.

9. Transmission of electrical energy through space requires two forms of energy; they are:

   a. electrical and atomic.
   b. magnetic and sound.
   c. sound and electrical.
   d. electrical and magnetic.

10. A collapsing magnetic field around a conductor produces:

    a. electrical energy.
    b. sound energy.
    c. a strong magnet.
    d. a very accurate compass.

11. Wavelength of an electromagnetic wave tells us:

    a how big the wave is.
    b. how much energy the wave contains.
    c. the space occupied by one cycle.
    d. the distance a radio wave is transmitted.

12. Radio waves travel at:

    a. the speed of light or 186,000 miles per second.
    b. different speeds; lower frequencies travel slower.
    c. the speed of sound.
    d. varying speeds depending on the density of the air.

13. The range or distance between the radio transmitter and receiver may be extended by:

    a. shouting louder into the microphone.
    b. the effect of earth and atmosphere on the path of radio waves.
    c. increasing the number of transmissions.
    d. transmitting the radio wave through salt water.

14. Radar provides information about:

    a. distance to a target.
    b. direction to a target.
    c. location of a target.
    d. all the above.

15. A target is located 1,860 miles from a radar antenna. The time between the transmission of the pulse and the return of the received pulse is: (Remember, the speed of light is 186,000 miles per second.)

    a. .01 second.
    b. .02 second.
    c. 1 second.
    d. 2 seconds.

16. Sonar and radar are similar in principle. The result of this is:

    a. sonar operators make very good radar operators.
    b. radar operators require more training about electrical equipment than sonar operators.
    c. the way that targets are detected and located are similar; however, different types of energy are used for radar and sonar.
    d. if a ship is equipped with radar it does not need sonar.

17. Three things are required to produce a sound. These are:

    a. an electrical power source, antenna, and receiver.
    b. compression, rarefraction, transmitting medium.
    c. sound source, medium, receiver or detector.
    d. source, compression, rarefraction.

18. Sound travels:

    a. about four times faster in water than in air.
    b. at the speed of light.
    c. at a constant 1,100 feet per second or 750 miles per hour.
    d. at a speed that depends on the amplitude or size of the sound wave.

19. Sound waves bend or refract due to:

    a. temperature.
    b. salt or salinity.
    c. pressure.
    d. all of the above.

20. Two types of sonar are used. These are:

    a. high frequency and low frequency.
    b. high amplitude and low amplitude.
    c. active and passive.
    d. sound pulse generators and active.

TRUE OR FALSE QUESTIONS:

T F

1. Electrical and electronic equipment is only used at night and in bad weather. ___ ___

2. The sound we hear on the radio or television is a good example of a radio wave. ___ ___

3. Electrons circle the nucleus of an atom similar to the way planets circle the sun. ___ ___

4. We make the most use of static electricity in electrical devices and equipment. ___ ___

5. Positively charged particles attract each other and negatively charged particles repel each other. ___ ___

6. Electrons do not flow through insulators. ___ ___

7. Electrical energy and magnetic energy often occur together. ___ ___

8. We can find the frequency of an electromagnetic wave if we know the number of cycles that occur in one second. ___ ___

9. The light we see is really a form of electromagnetic energy. ___ ___

10. By knowing the exact direction to one radio transmitter we could pinpoint our exact location. ___ ___

11. The transmitted and returned pulse from a radar travels at twice the speed of light. ___ ___

12. An area that is a high density of air molecules is called a "compression." ___ ___

13. Sound will travel faster in warm water than in cold water. ___ ___

14. The less salt in the water, the faster sound waves will travel. ___ ___

15. Sound waves like radio waves do not lose energy very quickly. ___ ___

VOCABULARY SKILLS:

Define the following vocabulary words used in the chapter. Then write an original sentence using each word.

1. mechanical energy
2. heat energy
3. light energy
4. molecule
5. electrical energy
6. amber
7. atom
8. nucleus
9. proton
10. neutron
11. electron
12. static electricity
13. current electricity
14. conductor
15. insulator
16. circuit
17. electromagnetic
18. refraction
19. medium
20. rarefraction

BRAIN TEASERS:

1. Describe the composition of an atom. Explain the positive and negative charged particles and the forces that keep the electrons revolving in regular orbits.

2. How does electricity flow and what are some common ways to produce electrical energy?

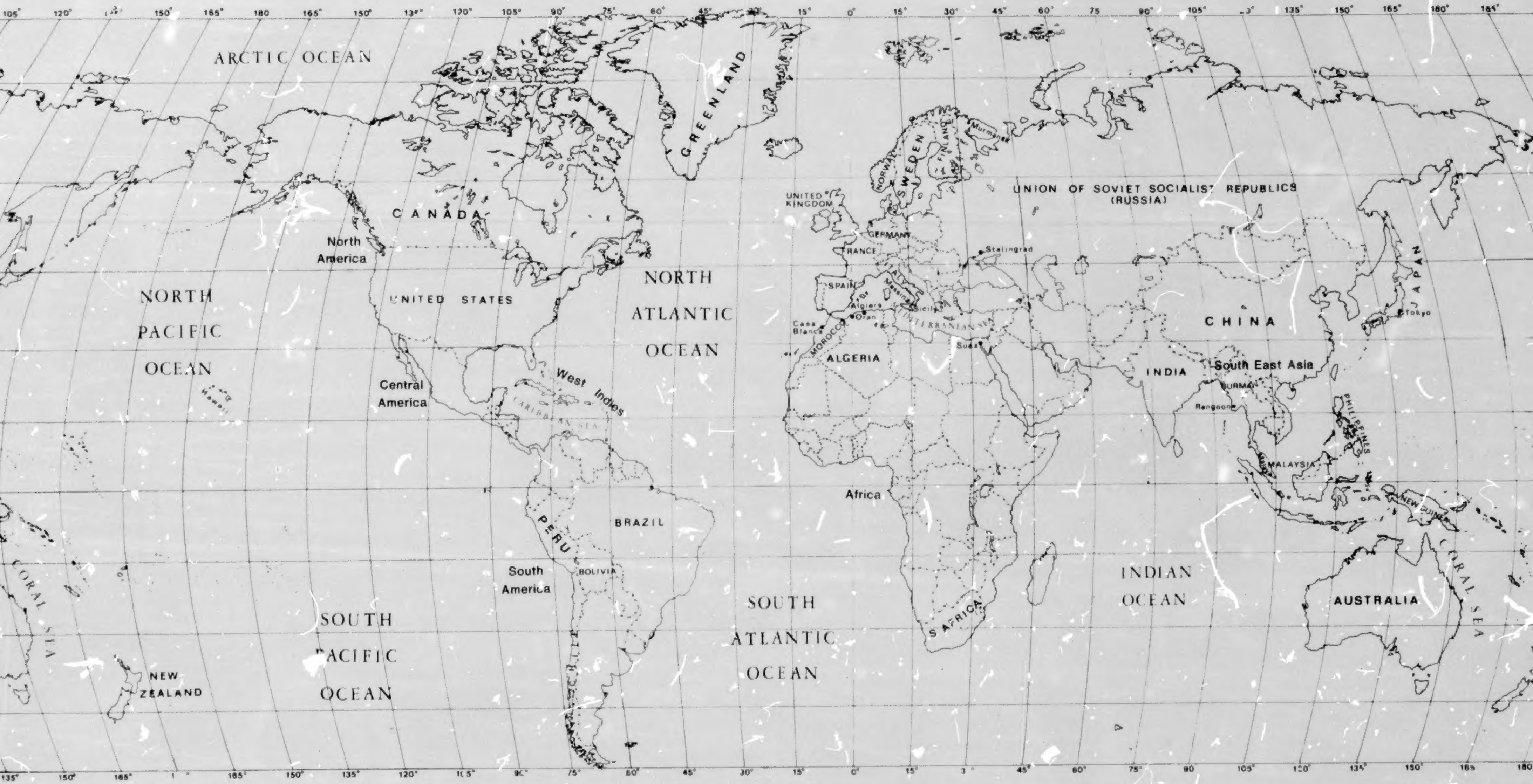
3. What are the main characteristics of a radio wave?

4. Where was the word "Radar" derived? What is the basic principle of radar?

5. Discuss and describe how radar may be used to assist the shiphandler. What are the advantages of using radar?

6. Explain how a sound pulse travels through the water at different pressure levels, different temperatures, and different levels of salinity. From this discussion show some of the difficulties a sonar operator must deal with for accurate target detecting and ranging.

7. An active sonar detects a submarine at a range of 3,200 yards. It takes 4 seconds from the time the underwater pulse is transmitted and the echo is received. A passive sonar receives the noise from the submarine's propeller in 2 seconds. Explain why the active sonar sound pulse takes 4 seconds while the passive sonar only requires 2 seconds.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UNITED STATES
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Hawaii
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CARIBBEAN SEA
NORTH ATLANTIC OCEAN
UNITED KINGDOM
NORWAY
SWEDEN
FINLAND
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GERMANY
FRANCE
SPAIN
ITALY
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Sicily
Algiers
Oran
Casa Blanca
MOROCCO
ALGERIA
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MALAYSIA
NEW GUINEA
AUSTRALIA
CORAL SEA
INDIAN OCEAN
Africa
S AFRICA
BRAZIL
PERU
BOLIVIA
South America
SOUTH PACIFIC OCEAN
SOUTH ATLANTIC OCEAN
NEW ZEALAND
CORAL SEA
135°
150°
165°
165°
150°
135°
120°
90°
75°
60°
45°
30°
15°
0°
15°
45°
60°
75°
90
105°
120°
135°
150°
180

GLOSSARY

GLOSSARY

Absolute Zero: temperature at which heat is thought to be completely absent

Academic: having to do with school

Accountability: under the obligation to report or explain action

Accurate: free from error

Advection: a mass of warm air passing first over warm water and then over cooler water, forming fog

Agonizing: very painful

Air mass: a huge bubble of cold or warm air traveling over the earth's surface

Air patrols: planes flown to hunt and sink submarines

Allies: those who are united with you especially by treaty. (During World War II, England, the United States, and Russia were allies.)

Altitude: height

Amber: a hard yellowish to brownish transparent fossilized resin

Amphibious force: naval and landing force, together with supporting forces, who are trained, organized, and equipped for amphibious operations

Amphibious warfare: warfare waged by using naval and landing forces embarked in ships or craft, involving a landing on a hostile shore

Anemometer: an instrument used to measure wind direction and speed

Aneroid barometer: a barometer with a needle connected to the top of a metal box in which a partial vacuum is maintained; a change in atmospheric pressure causes the top of the box to bend in or out, thus moving the needle

Annoyance: something that makes you uncomfortable

Anvil: last stage of thunderstorm where down-drafts take over, rain falls heavily, and storm becomes less violent

Appeasement: trying to keep peace by giving in to the increasing demands of others

Assets: total personal property

Asteroids: small planets between Mars and Jupiter that orbit around the sun

Atmosphere: the whole mass of air surrounding the earth

Atom: the smallest part of an element

Axis: 1. imaginary line on which the earth rotates 2. the alliance of Germany, Japan, and Italy during World War II

Bar: unit of measurement of atmospheric pressure reported by inches of mercury under pressure; 29.92 inches = 1 bar = 1000 millibars

Barograph: an aneroid barometer that makes a continuous record of barometric pressure

Barometer: device used to measure air pressure by measuring the weight of air

Beachhead: a foothold area on an enemy's shore that is occupied to make further landing of troops and supplies possible

Beaufort Wind Scale: scale devised by Admiral Sir Francis Beaufort to rate winds according to how forceful they are

Belligerent: a warlike or aggressive attitude. (The participants in a battle are referred to as belligerents.)

Big Bang Theory: explanation of how the universe was formed that says matter was originally contained in a compact sphere which suddenly exploded

Boast: brag

Bondage: imprisonment, slavery

Calculated: carefully thought out or planned

Celsius scale: a scale on a thermometer for measuring temperature. On this scale the boiling point of water measures 100 degrees and the freezing point of water measures 0 degrees

Centers of action: secondary wind circulation systems that remain in the same general areas throughout the year. As high and low pressure areas, they act as great wind machines, e.g., the Bermuda High

Chemosphere: small transition zone above the stratosphere that serves as a protective shield

Chromosphere: lower part of the sun's atmosphere

Circuit: a path for current flow

Coalescence: the joining together of microscopic water droplets in a cloud

Coastal convoy: protective escort of merchant ships by warships as they traveled up and down the coast of the United States

Cold snap: the dominance of polar air over previously dominant warmer tropical air

Compromise: to agree to make concessions

Comrades: companions

Conductor: material that electrons move easily through such as copper, silver, or gold

Conquest: the act of gaining something by using force

Constellations: groups of stars

Convection: hot air rising

Convergence: different air masses coming together

Coriolis effect: the prevention of wind currents from flowing directly North or South by the spinning of the Earth on its axis from West to East

Corona: halo-like layer of the sun visible during solar eclipses

Craters: depressions on the surface of the moon or earth believed to be formed by meteorites hitting the surface

Current electricity: steady flow of free electrons from a negative source to a positive source over a long period of time

Demolition: destruction by explosion

Designate: name; appoint

Dew point: the temperature to which air must be cooled for condensation to occur

Dictator: in government, a person who takes absolute control without the free consent of the people or any other right

Diffraction: natural bending of radio waves over the horizon

Disarmament: the reduction or limitation of the size and equipment of a country's armed forces

Discipline: training that develops self-control, character, and efficiency

Diversion(ary): an attack or pretended attack that draws the attention and force of an enemy from the point of the main operation

Doldrums zone: area at the equator where air heats up higher than anywhere else on earth

Dominate: to rule or control

Eccentric: irregular path of planet around the sun (or another star)

Economy: a term used when referring to the production of goods and services, their distribution and consumption

Elaborate: detailed

Electrical energy: the result of moving electrons out of their circular paths around the atom so that they move freely in another material

Electromagnetic: having to do with magnetism developed by a current of electricity

Electromagnetic energy: x-rays, gamma rays, ultra-violet, visible light, infrared and radio waves radiated from the stars

Electrons: particles circling the nucleus of the atom that have small negative electronic charges

Enormous: of great size

Evade: to escape by trickery or cleverness

Exosphere: highest layer of atmosphere that begins at about 500 miles and goes up to about 18,000 miles; has extremely hot and cold temperatures

Express: high speed

Eye of a hurricane: the center of a hurricane where the weather is calm

Fahrenheit scale: a scale on a thermometer for measuring temperature. On this scale the boiling point of water measures 212 degrees and the freezing point of water measures 32 degrees

Familiarity: very relaxed, personal behavior

First or cumulus stage: first phase of a thunderstorm where air over earth heats up and rises; as it rises water vapor condenses which causes a cumulus cloud to form

Fleet: the largest organization of warships under the command of a single officer

Flying boats: type of plane designed for hunting and sinking submarines

Free City of Danzig: a self-governing territory which included the Polish seaport of Danzig. (Hitler invaded in 1939 and made it a part of Germany. It is now part of Poland.)

Front: a line that divides two different air masses that have collided

Galaxies: huge collections of stars, star clusters, dust, and gas held together by gravity

Galileo: Italian scientist who lived 1564-1642 who was the first to use the telescope to observe heavenly bodies

General circulation: the circulation of the earth's atmosphere formed by the four major prevailing winds; the Doldrums, the Trade Winds, the Prevailing Westerlies, and the Polar Easterlies

Giants: stars that are remarkable for their large size and which may be as much as 100 times brighter than our sun

Heat energy: the form of energy that causes heat, e.g., warmth from a fire

Hedgehog: a bomb thrown into the water designed to explode on contact with a submarine

Hertzsprung-Russell Diagram: system of classifying stars according to their real brightness and temperature

High-altitude balloons: hot air balloons flown at high altitude used to observe the stars

Horse latitudes: where sinking, cooling, equatorial air forms areas of higher pressure around the earth. In the Northern hemisphere, 30 degrees N. latitude; in the Southern hemisphere, 30 degrees S. latitude

Humidity: water vapor in the air

Hurricane: violent storm formed as a spinning circle of wind around a low pressure area

Hydrological cycle: the eternal process of evaporation, condensation, and precipitation

Hygrometer: an instrument which measures wetness in the air

Hygroscopic nuclei: dust

Inflict: to give or cause (pain, wounds, etc.)

Inform: to supply (oneself) with the knowledge or information necessary to solve a problem

Initiate: to begin; to start going

Inland: the interior part of a country or region

Insulators: materials that do not permit electrons to flow such as wood or rubber

Integrity: uprightness, honesty

Intercept: to stop an enemy's progress

International: between or among two or more nations

Intertropical front: a little front occurring in the Doldrums producing squalls

Invade: to enter forcefully, as an enemy

Ionosphere: area of the atmosphere composed of stratosphere, mesosphere, and thermosphere

Isolationism: when a nation decides to maintain its rights and interests without any formal allies

Jet streams: fast-moving currents of air in the tropopause

League of Nations: the first major organization of the states of the world dedicated to peace and international cooperation. It was founded after World War I in 1920

Leonardo de Vinci: a great scientist and artist of the 15th century

Light energy: the form of energy that brightens a room

Light year: a measurement of stellar distances; the distance that light travels in a year, about 9.5 million kilometers

Logistics: the system of supplying services and supplies to the fleet ships engaged in warfare far from a home port

Luminosity: absolute or real brightness of a star

Magnetic field: region near a magnetic object or electrical current in which magnetic forces can be detected

Main sequence stars: stars represented by points that fall within the diagional band running from lower right to upper left of the Hertzsprung-Russell Diagram; the majority of stars studied fall in this group

Maria: dark regions on the surface of the moon that look like seas

Mature stage: second phase of a thunderstorm characterized by strong updrafts and downdrafts within the cloud causing thunderstorms to occur as warm and cold air currents smash together

Mechanical energy: the result of moving objects such as the turning of a wheel

Medium: material such as water through which energy (for example, sound waves) or force can pass

Mercurial barometer: a column of mercury used for measuring the air's weight which measures 29.92 inches at sea level at sea latitude 45 degrees

Mesosphere: region of atmosphere with extreme temperature changes that begins at an altitude of 30 miles and reaches to about 50 miles

Meteor: a very small stony or metallic body traveling through space that burns up when it enters the earth's atmosphere

Meteorites: stony or metallic bodies traveling through space that do not burn completely when entering the atmosphere and eventually crash into the earth's surface

Meteorologists: scientists who study the atmosphere, weather, and weather forecasting

Meteorology: scientific study of the atmosphere

Migratory lows: moving low-pressure areas frequently found just in front of the polar highs

Milky Way: 1. name of our galaxy
2. thick band of stars located in the center of our galaxy

Millibar: one-thousandth of a bar

Molecules: the smallest particles of a substance

Monsoon: very strong seasonal winds

Moral: right instead of wrong

Mulberries: gigantic artificial harbors used during the Normandy invasion

Mutual: shared, in common

Neutrons: particles in the center of the nucleus that have no electrical charges

Nuclear fusion: process where two atomic nuclei are joined together to form one nucleus

Nucleus: the center of an atom

Obedience: doing what is asked of you

Objectives: goals or aims

Obligations: social or legal duties

Obstacles: things that are in the way

One atmosphere: barometer measure of 29.92 inches (or 760 millimeters), the normal air pressure at sea level

Orbit: path of one body around another

Ozone layer: a protective layer of gas (formed from oxygen) found in the stratosphere

Perimeter: the outer boundary line of a given area as in the Japanese perimeter

Personnel: persons employed in any work

Perspective: seeing events or things in proper relationship to one another

Phases: the changes in the visible fraction of the illuminated surface of the moon or a planet

Photosphere: extremely bright surface layer of the sun

Photosynthesis: process by which plants use sunlight to produce food

Pinpoint: exceptionally accurate

Polar front: a very cold air mass sweeping down over the earth from the North or South Pole

Precipitation: forms of water, e.g., rain, sleet, hail, and snow

Prime Minister Chamberlain: English prime minister who tried to deal peacefully with the Germans before World War II

Priority: being ahead in importance

Prism: a transparent body bounded in part by two plane faces that are not parallel; used to bend or disperse a beam of light

Privilege: a right not granted to others

Prominences: giant streamers of hot gases that arch far out into space before they return to the sun's surface

Propaganda: information or ideas spread deliberately to further one's cause or to damage an opposing cause

Protected harbors: harbors protected by mines, blimps, and surface vessels where ships stayed at night

Protons: particles in the center of the nucleus that have small positive electrical charges

Pulsars: pulsating radio sources deep in space

Radar: a technique for measuring the direction and distance to an object by transmitting radio waves to the object and analyzing the reflected signals

Radar telescopes: a telescope which bounces radar pulses off the planets; collects and analyzes them

Radiant energy: the energy given off by an object, hot or cold, e.g., the heat from a fire

Radio telescope: a telescope which collects and measures radio-frequency radiation from various light sources

Rarefraction: region of fewer air molecules in sound waves

Refraction: bending of radio waves by the atmosphere

Relative humidity: the amount of water vapor in the air expressed as percentage of the maximum amount that the air could hold at a given temperature

Remote: out of the way

Repelled: driven or forced back

Resources: natural source of wealth like oil or coal

Restricted: liited

Retract: to pull or draw back

Satellite: a small object in orbit around a large object; a moon

Sea lanes: an established sea route

Secured: occupied and made safe against enemy threat

Solar flares: sudden eruptions of very hot gas appearing as bright spots on the sun

Solar wind: tremendous stream of highly charged particles that the sun sends out into space

Sonar: an electronic device with transmitting and receiving elements that uses sound waves in water to find the location of objects; used like radar

Sonobuoy: a round receiver-transmitter dropped from an aircraft to pick up submarine noises and send these back to the plane

Spectra: plural form of spectrum

Spectrograph: an instrument which makes photographs of light from various light sources

Spectrum: arrangement of colors by wavelength when light is split apart by a prism

Squalls: thunderstorms resulting from inter-tropical fronts

Static electricity: build up of positive and negative electrical charges

Straits: narrow waterways connecting two large bodies of water

Strategies: the science or art of planning or directing large military movements and operations

Stratosphere: that part of the earth's atmosphere which reaches to 30 miles above the surface of the earth; characterized by low temperature and little water vapor

Subgiants: class of stars on the Hertzsprung-Russell diagram ten times brighter than our sun

Sunspots: violent magnetic storms on the surface of the sun that appear as dark spots on the solar surface

Supergiants: huge stars that are as much as one million times as bright as the sun

Telescope: an optical device that uses a series of mirrors and lenses to collect light from a distant source

Temperate zone: the area of the Earth lying between latitudes 30 degrees and 50 degrees where most of the people in the world live, and which is characterized by sudden changes in the weather

Theater: the whole land, sea, and air area that is or may be involved directly in a war's operation

Thermometer: an instrument which measures heat

Thermosphere: layer of atmosphere about 50 miles above the earth's surface where air is hot, thin, and electrically charged

TIROS: an acronym for "Television and Infra-Red Observation Satellite"; provided information used in accurate weather forecasting

Tolerated: put up with; allowed

Tornado: very destructive and unpredictable wind storm

Trade winds: steady winds that blow from the horse latitudes south to the equator

Transatlantic convoy: merchant ships or supply ships escorted by warships and sometimes aircraft crossing or extending across the Atlantic Ocean

Transpiration: the process of the evaporation of water from the leaves of green plants

Tropopause: border zone of air over the troposphere, divided into three overlapping areas; tropical, extra-tropical, and Arctic

Troposphere: lowest part of the earth's atmosphere that is 5 to 11 miles above the surface of the earth and which produces our weather conditions

Ultraviolet: light waves beyond the visible spectrum, shorter than visible light, and longer than X-rays

Uncharted: unmapped

Utopia: a perfect society or place which does not exist

Van Allen radiation belts: belts of electrically charged air in the exosphere at altitudes of 2400 miles and 9600 miles

Vapor: gaseous state of water

Viking Lander: space probe used to explore other planets

Vision: the ability to see with the eyes, often used to suggest being able to see issues clearly

Voluntarily: done by one's free choice

Waterspout: the water sucked up by a tornado moving over a body of water

ANSWERS TO EXERCISES

CHAPTER I: THE NAVY IN WORLD WAR II

Multiple Choice Questions (p.19):

1. (a) 2. (a) 3. (c) 4. (c) 5. (a) 6. (b) 7. (a) 8. (b) 9. (a) 10. (a)

True or False Questions (p. 20):

1. (T) 2. (T) 3. (F) 4. (T) 5. (T) 6. (T) 7. (T) 8. (F) 9. (T) 10. (F)

Vocabulary Skills (p. 21):

1. allies
2. isolationism
3. inland
4. vision
5. fleet
6. dictator
7. disarmament
8. perspective
9. Free City of Danzig
10. logistics
11. invade
12. strategy
13. League of Nations
14. amphibious warfare
15. international

Multiple Choice Questions (p. 37):

1. (c) 2. (a) 3. (b) 4. (a) 5. (a) 6. (a) 7. (a) 8. (b) 9. (b) 10. (b)

True or False Questions (p. 38):

1. (F) 2. (T) 3. (F) 4. (T) 5. (F) 6. (F) 7. (T) 8. (T) 9. (F) 10. (T)

Vocabulary Skills (p. 39):

1. axis
2. belligerent
3. resources
4. transatlantic
5. conquests
6. convoy
7. dominate
8. assets

Multiple Choice Questions (p. 49):

1. (b) 2. (a) 3. (a) 4. (a) 5. (a) 6. (c) 7. (b) 8. (a)

True or False Questions (p. 50):

1. (T) 2. (T) 3. (F) 4. (F) 5. (T)

Vocabulary Skills (p. 51):

1. coastal convoy
2. protected harbors (anchorages)
3. radar, sonobuoy(s)
4. flying boat
5. Prime Minister Chamberlain
6. sea lanes
7. hedgehog
8. logistics

Multiple Choice Questions (p. 67):

1. (a) 2. (c) 3. (b) 4. (b) 5. (b) 6. (b) 7. (b) 8. (b) 9. (b) 10. (b)

True or False Questions (p. 68):

1. (F) 2. (T) 3. (T) 4. (F) 5. (T) 6. (F) 7. (T) 8. (F) 9. (F) 10. (F)

Vocabulary Skills (p. 69):

1. retract
2. obstacle
3. enormous
4. beachhead(s)
5. theater

Multiple Choice Questions (p. 81):

1. (c) 2. (b) 3. (b) 4. (b) 5. (c) 6. (c) 7. (c) 8. (c)

True or False Questions (p. 82):

1. (T) 2. (F) 3. (T) 4. (T) 5. (F) 6. (T) 7. (F) 8. (F) 9. (T) 10. (F)

Vocabulary Skills (p. 83):

1. objective
2. initiate(d)
3. compromise
4. accurate
5. boast
6. elaborate
7. diversion(ary)

Locations in the Pacific (p. 84):

1. attempt to cut off sea lanes to Australia
2. Rabaul
3. Midway
4. Kiska
5. Borneo
6. Port Moresby
7. Corregidor

Multiple Choice Questions (p. 109):

1. (a) 2. (c) 3. (c) 4. (a) 5. (b) 6. (c) 7. (a) 8. (a) 9. (c) 10. (b)

True or False Questions (p. 110):

1. (T) 2. (F) 3. (T) 4. (T) 5. (F) 6. (F) 7. (F) 8. (F) 9. (F) 10. (T)

Vocabulary Skills (p. 111):

1. repel
2. express
3. demolition
4. perimeter
5. uncharted
6. restricted
7. secured
8. strait

Multiple Choice Questions (p.121):

1. (b) 2. (b) 3. (b) 4. (a) 5. (a) 6. (a) 7. (b) 8. (a)

True or False Questions (p. 122):

1. (T) 2. (T) 3. (F) 4. (F) 5. (F) 6. (T) 7. (F) 8. (F) 9. (F) 10. (T)

Vocabulary Skills (p. 122):

1. pinpoint
2. intercept

CHAPTER II: NAVAL LEADERSHIP

Multiple Choice Questions (p. 133):

1. (c) 2. (b) 3. (c) 4. (a) 5. (b) 6. (a) 7. (b) 8. (a) 9. (a) 10. (b)

True or False Questions (p. 134):

1. (T) 2. (T) 3. (F) 4. (T) 5. (T) 6. (F) 7. (T) 8. (F) 9. (F) 10. (F)

Vocabulary Skills (p. 135):

1. Annoyance: something that makes you uncomfortable
2. Agonizing: very painful
3. Discipline: training that develops self-control, character, and efficiency
4. Moral: right instead of wrong
5. Obedience: doing what is asked of you
6. Obligation: social or legal duty
7. Utopia: a perfect society or place which does not exist

Fill in the Blanks (p. 135):

1. discipline 2. obligation 3. utopia
4. obedience 5. agonizing 6. annoyance
7. moral

Multiple Choice Questions (p. 143):

1. (b) 2. (a) 3. (c) 4. (a) 5. (a) 6. (a) 7. (a) 8. (b) 9. (a) 10. (b)

True or False Questions (p. 144):

1. (T) 2. (T) 3. (F) 4. (T) 5. (T) 6. (T) 7. (T) 8. (F) 9. (T) 10. (T)

Vocabulary Skills (p. 144):

1. Academic: having to do with school
2. Informed: having the knowledge or information necessary to solve a problem
3. Integrity: uprightness, honesty
4. Priority: being ahead in importance
5. Calculated: carefully thought out or planned

Fill in the Blanks (p. 145):

1. integrity 2. priority 3. informed
4. academic 5. calculated

Multiple Choice Questions (p. 153):

1. (c) 2. (b) 3. (c) 4. (b) 5. (a) 6. (a) 7. (a) 8. (b) 9. (b) 10. (a)

True or False Questions (p. 154):

1. (T) 2. (T) 3. (T) 4. (F) 5. (F) 6. (F) 7. (F) 8. (T) 9. (T) 10. (T)

Vocabulary Skills (p. 155):

1. Accountability: under the obligation to report or explain action
2. Bondage: imprisonment, slavery
3. Comrades: companions
4. Evade: to escape by trickery or cleverness
5. Mutual: shared, in common
6. Propaganda: information or ideas spread deliberately to further one's cause or to damage an opposing cause
7. Voluntarily: done by one's free choice

Fill in the Blanks: (p. 155):

1. comradeship	2. voluntarily	3. bondage
4. propaganda	5. evade	6. mutual
7. accountable		

Multiple Choice (p. 163):

1. (a) 2. (c) 3. (a) 4. (c) 5. (a) 6. (b) 7. (b) 8. (a) 9. (a) 10. (a)

True or False Questions (p. 164):

1. (F) 2. (T) 3. (T) 4. (F) 5. (T) 6. (T) 7. (T) 8. (T) 9. (T) 10. (T)

Vocabulary Skills (p. 165):

1. Designate: name; appoint
2. Familiarity: very relaxed, personal behavior
3. Inflict: to give or cause (pain, wounds, etc.)
4. Personnel: persons employed in any work
5. Privilege: a right not granted to others
6. Tolerate: put up with; allow

Fill in the Blanks (p. 165):

1. tolerate
2. personnel
3. inflict
4. privilege
5. familiarity
6. designate

CHAPTER III: METEOROLOGY

Multiple Choice Questions: (p. 173):

1. (b) 2. (a) 3. (b) 4. (b)

Match the Following: (p. 173):

1.f, 2.e, 3.d, 4.c, 5.g, 6.b, 7.a

Study Questions (p. 183):

1. e. Exosphere
   d. Thermosphere
   c. Mesosphere
   b. Stratosphere
   a. Troposphere

2. a. 5 to 11 miles thick; weather is present here
   b. 30 miles; no clouds
   c. 30 to 50 miles; extreme temperature change
   d. 50 to 500 miles; electrically charged air; thinnest layer
   e. highest layer; 500 to 18,000 miles

3. (c)

4. (b)

Vocabulary Skills (p. 183):

1. humidity: water vapor in the air.

2. relative humidity: the amount of water vapor in the air expressed as a percentage of the maximum amount that the air could hold at a given temperature.

3. convection: hot air rising.

4. ozone layer: a protective layer of gas (formed from oxygen) found in the stratosphere. It is also called the chemosphere.

5. jet stream: fast-moving currents of air in the tropopause.

Hidden Message (p. 184):

1. dew
2. atmosphere
3. nitrogen
4. equator
5. humidity
6. temperature
7. think
8. troposphere
9. tropopause
10. stratosphere
11. exosphere
12. water vapor

Message: water/vapor/in/our/air/heat/make/our/weather

Study Questions (p. 195):

1. (c) 2. (b) 3. (b) 4. (b) 5. Heat 6. water vapor 7. a. acts as a blanket. b. provides moisture we need to survive. 8. a. increases b. 30.4 c. 100% relative humidity d. 13.09 grams per cubic meter e. 53% 9. (a) 10. (b) 11. (c) 12. rise, fall 13. (c) 14. (a) Celsius (b) Fahrenheit 15. C = 5/9 (F-32), F = 9/5 (C + 32).

Vocabulary Skills (p. 197):

1. One Atmosphere: Barometer measure of 29.92 inches (or 760 millimeters), the normal air pressure at sea level.

2. Millibar: One-thousandth of a bar.

3. Bar: Unit of measurement of atmospheric pressure reported by inches of mercury under pressure 29.29 inches = 1 bar = 1000 millibars.

4. Mercurial Barometer: A column of mercury used for measuring the air's weight which measures 29.92 inches at sea level at sea latitude 45°.

5. Aneroid Barometer: A barometer with a needle connected to the top of a metal box in which a partial vacuum is maintained; a change in atmospheric pressure causes the top of the box to bend in or out, thus moving the needle.

6. Barograph: An aneroid barometer that makes a continuous record of barometric pressure.

7. Radiant Energy: The energy given off by an object, hot or cold. For example, the heat from a fire.

8. Celsius Scale: A scale on a thermometer for measuring temperature. On this scale the boiling point of water measures 100° and the freezing point of water measures 0°.

9. Fahrenheit Scale: A scale on a thermometer for measuring temperature. On this scale the boiling point of water measures 212° and the freezing point of water measures 32°.

10. Dew Point: The temperature to which air must be cooled for condensation to occur.

11. Hydrological Cycle: The eternal process of evaporation, condensation, and precipitation.

12. Transpiration: The process of the evaporation of water from the leaves of green plants.

VOCABULARY WORD SEARCH (p. 198)

O	B	D	F	H	M	I	L	L	I	B	A	R	O	P	Q	R	S
C	N	E	G	I	J	Z	Y	X	W	V	T	U	A	C	F	G	H
X	W	E	Y	U	K	L	M	N	B	A	R	O	M	E	T	E	R
Y	Z	B	A	R	T	S	T	R	Q	P	E	D	B	I	K	J	E
B	U	O	I	T	E	A	R	A	C	Y	J	O	N	M	L	F	Z
C	D	A	F	C	M	N	A	N	H	P	A	R	G	O	R	A	B
O	N	N	C	L	A	O	N	O	A	N	C	L	A	Y	M	H	I
D	C	E	L	S	I	U	S	S	C	A	L	E	H	I	K	R	K
I	V	R	A	D	Y	I	P	P	K	K	I	M	O	L	L	E	E
H	A	O	P	P	Y	D	I	V	H	D	D	A	V	I	D	N	W
F	O	I	R	C	H	S	R	A	S	E	M	A	I	L	L	H	I
T	C	D	U	R	T	I	A	S	C	X	R	E	L	A	Y	E	T
T	N	E	R	B	I	K	T	D	E	W	K	E	I	M	N	I	O
K	A	T	H	Y	J	O	I	A	N	P	H	O	M	E	I	T	S
I	S	I	T	R	A	E	O	H	E	O	H	T	E	R	E	H	W
L	Y	O	U	V	T	E	N	O	O	I	D	A	D	M	O	M	I
O	G	R	A	D	I	A	N	T	E	N	E	R	G	Y	Y	R	A
L	N	G	I	Y	X	Z	Y	B	E	T	H	Z	Y	T	E	M	A

Study Questions (p. 209):

1. (c)

2. a. Fog is formed when a mass of cool air moves in and mixes with warm air that has a high relative humidity. Fog forms when the temperature of the damp air drops to its dew point. Fog is simply a big cloud lying close to the ground.
    b. (1) Moist air
        (2) Breeze
        (3) A combination of warm and cool temperatures

3. (c)

4. a. Stratus
    b. Cumulus
    c. Cirrus
    d. Nimbus

5. Family I: High
    a. Cirrus
    b. Cirro-cumulus
    c. Cirro-stratus

    Family II: Middle
    a. Alto-Cumulus
    b. Alto-stratus

    Family III: Low
    a. Strato-cumulus
    b. Stratus
    c. Nimbo-stratus

    Family IV: Towering
    a. Cumulus
    b. Cumulo-nimbus

6. a. Cirrus
    b. Cumulus
    c. Cirro-stratus
    d. Cumulo-nimbus

7. a. Fog
    b. Snow
    c. Dew
    d. Frost
    e. Rain
    f. Hail

8. a. Coalescence
    b. Advection
    c. Fog
    d. Altitude
    e. Hygroscopic Nuclei. Mystery Word: Precipitation

Vocabulary Skills (p. 212):

1. Precipitation: Forms of water; e.g., rain, sleet, hail, and snow.

2. Hygroscopic nuclei: Dust

3. Altitude: Height

4. Coalescence: The joining together of microscopic water droplets in a cloud.

5. Advection: A mass of warm air passing first over warm water and then over cooler water forming fog.

Study Questions (p. 225):

1. a. N.E. b. S.W. c. S.W. d. N.W.

2. (a) Polar easterlies (b) Westerlies (c) N.E. Trade winds (d) S.W. Trade winds (e) Westerlies (f) Polar Westerlies.

3. (c) 4. (a) T (b) T 5. (c) 6. outward

7.

	Highs	Lows
Weather	Fair	Cloudy, rain or snow
Air Circulation	Clockwise in N.H. counter-clockwise in S.H.	Counter-clockwise in N.H. Clockwise in S.H.
Winds	Light	Strong
Temperature	Cooler	Changing

8. (c) 9. (a) 10. (c) 11. (a) 12. (a) 13. (c) 14. (c) 15. (c)

Vocabulary Skills (p. 227):

1. Coriolis Effect: The prevention of wind currents from flowing directly North or South by the spinning of the Earth on its axis from West to East.

2. Temperate Zone: The area of the Earth lying between latitudes 30° and 50° where most of the people in the world live, and which is characterized by sudden changes in the weather.

3. Migratory Lows: Moving low-pressure areas frequently found just in front of the polar highs.

4. Horse Latitudes: Where sinking, cooling, equatorial air forms areas of higher pressure around the earth. In the Northern Hemisphere 30° N. latitude; in the Southern Hemisphere, 30° S. latitude.

5. General Circulation: The circulation of the earth's atmosphere formed by the four major prevailing winds: the Doldrums, the Trade Winds, the Prevailing Westerlies, and the Polar Easterlies.

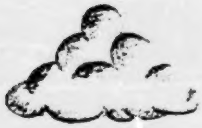
6. Centers of Action: Secondary wind circulation systems that remain in the same general areas throughout the year. As high and low pressure areas, they act as great wind machines, e.g., the Bermuda High.

Study Questions (p. 241):

1. (a) Intertropical Convergence Zone (b) Arctic Frontal Zone (c) Polar Frontal Zone

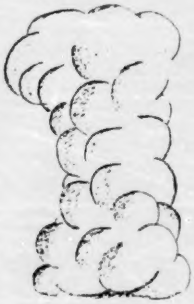
2. Intertropical Convergence Zone

3. a)



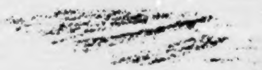
Cumulus Cloud Stage

b)



Mature Stage

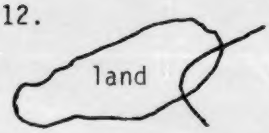
c)



Anvil Stage

4. T 5. (a) 6. (a) 7. (b) 8. (c) 9. (a) tropical depression (b) tropical storm (c) hurricane 10. (b) 11. Counterclockwise, clockwise.

12.



First, N.W. Movement, Then Curving N.E.

13. (a) Prevailing westerlies (b) land (c) temperature 14. (c) 15. (1) tropical depression (2) hurricane (3) cold snap (4) fog.

WORD SEARCH (p. 243)

P	O	N	T	B	N	O	I	T	A	R	I	P	S	N	A	R	T
C	P	F	B	A	R	O	G	R	A	P	H	V	E	U	I	N	P
B	S	A	C	R	N	H	G	L	Z	X	O	T	N	O	R	F	O
A	Y	H	O	O	S	I	F	R	A	D	S	A	T	J	I	H	L
N	C	R	A	M	N	F	O	D	A	I	K	Q	I	M	J	M	I
R	R	E	L	E	C	R	I	C	G	M	C	E	U	I	C	G	T
G	O	N	E	T	A	R	O	O	I	K	E	J	H	A	E	R	L
S	M	H	S	E	E	N	L	N	C	Y	L	O	N	T	L	M	E
A	E	E	C	R	D	O	R	V	B	D	S	J	N	A	L	L	B
Q	T	I	E	E	R	B	I	E	N	E	I	A	E	C	O	L	N
B	E	T	N	O	M	R	B	C	I	J	U	O	R	S	N	O	E
L	R	S	C	C	R	S	A	T	H	E	S	B	R	A	R	A	L
N	E	T	E	O	A	I	T	I	R	M	T	H	Y	E	I	M	L
I	E	Y	A	N	I	G	E	O	I	E	E	R	M	A	N	O	A
M	H	A	C	I	C	H	L	N	O	I	T	C	E	V	D	A	N
U	P	P	A	Y	C	O	R	U	N	U	Z	S	Q	R	E	R	A
H	U	M	I	D	I	T	Y	E	F	Z	Y	U	I	R	L	G	V

Vocabulary Skills (p. 244):

1. Front: A line that divides two different air masses that have collided.

2. Squall: thunderstorm resulting from intertropical fronts.

3. Convergence: Different air masses coming together.

4. Cold Snap: The dominance of polar air over previously dominant warmer tropical air.

5. Waterspout: The sucking up of water by a tornado moving over a body of water.

6. Eye of a Hurricane: The center of a hurricane where the weather is calm.

CHAPTER IV

ASTRONOMY

Fill in Blanks (p. 253):

1. Spectrograph 2. Radio Telescope 3. Telescope 4. Radar Telescope

True or False Questions (p. 253):

1. F (Ancient man used the stars to navigate.) 2. T 3. F (In 1976 the Viking Landers explored Mars.) 4. F (The sand samples analyzed by the Viking Landers did not prove the existence of life on Mars.) 5. T 6. F (Observatories are located in remote places to avoid night-time glare and air pollution from large cities.) 7. T 8. T

Analogies (p. 254):

1. Mirror 2. Biologist 3. Projector

Vocabulary Skills (p. 254): Definitions given below. Sentences will vary.

1. Telescope: An optical device that uses a series of mirrors and lenses to collect light from a distant source.

2. Galileo: Italian scientist who lived 1564-1642 who was the first to use the telescope to observe heavenly bodies.

3. Spectrograph: An instrument which makes photographs of light from various light sources.

4. Spectrum: Arrangement of colors by wavelength when light is split apart by a prism.

5. Spectra: Plural form of spectrum.

6. Radio Telescope: A telescope which collects and measures radio-frequency radiation from various light sources.

7. Radar Telescope: A telescope which bounces radar pulses off the planets; collects and analyzes them.

8. Prisms: A transparent body bounded in part by two plane faces that are not parallel; used to bend or disperse a beam of light.

9. Pulsar: Pulsating radio sources deep in space.

10. High-Altitude Balloons: Hot air balloons flown at high altitude used to observe the stars.

11. Viking Lander: Space probe used to explore other planets.

12. Remote: out of the way.

WORD SEARCH (p. 255)

A	K	J	F	N	E	W	Y	K	I	M	N	O	P	X	Q	Z	R	S
B	S	L	M	N	K	E	V	W	N	I	Z	V	K	X	L	G	C	P
N	B	P	B	L	X	O	L	I	G	H	T	Y	E	A	R	S	O	E
K	I	H	E	A	I	F	S	T	R	E	E	S	W	I	M	L	N	C
I	K	P	P	C	F	H	A	P	S	E	S	K	Y	L	A	B	S	T
B	M	Y	A	D	T	P	Y	U	A	I	A	T	I	S	T	E	T	R
O	N	G	A	M	P	R	A	L	E	C	G	O	A	N	I	N	E	A
N	O	A	J	O	N	T	O	I	N	E	E	O	S	R	G	T	L	S
O	B	L	A	N	S	D	A	G	Y	I	L	P	T	O	S	I	L	S
Z	C	I	J	I	I	U	K	L	R	E	P	E	R	N	T	O	A	R
W	E	L	M	C	R	N	R	U	Y	A	D	R	O	O	T	H	T	P
V	G	E	A	R	A	I	R	M	E	T	P	A	N	E	B	N	I	N
M	F	O	R	I	S	V	O	I	M	E	E	H	O	I	G	E	O	I
E	K	E	I	T	O	E	F	N	M	L	Y	I	M	H	T	A	N	M
G	A	L	A	X	Y	R	I	O	E	E	O	N	Y	N	D	I	S	K
F	Z	E	Q	B	F	S	N	S	D	S	J	I	M	C	O	I	H	E
K	Y	U	A	E	O	E	F	I	V	C	I	H	P	Y	R	T	I	P
L	X	L	S	D	S	A	I	T	N	O	G	T	I	P	S	W	O	O
N	N	C	L	O	T	T	O	Y	R	P	N	O	N	G	R	A	S	N
C	Y	I	K	U	W	M	O	J	N	E	N	B	O	S	P	Q	R	T

Word Puzzle (p. 256):

A	S	T	R	O	N	O	M	E	R
1	2	3	4	5	6	7	8	9	10

Multiple Choice Questions (p. 265):

1. (c) 2. (c) 3. (c) 4. (a) 5. (b) 6. (b) 7. (d) 8. (b) 9. (c) 10. (d)

True/False Questions (p. 266):

1. T 2. T 3. F (Stars vary in brightness as well as color. 4. T 5. T 6. T 7. F (The Hertzsprung-Russell diagram is a way of classifying stars.) 8. F. (Our sun is relatively small compared to other stars on the H-R Diagram.) 9. F (The magnitude of a star refers to its brightness.) 10. F (Main sequence stars are medium-sized and bigger only than White Dwarfs.)

Vocabulary Skills (p. 267): Definitions given below. Sentences will vary.

1. Electromagnetic energy: X-rays, gamma rays, ultraviolet, visible light, infrared and radio waves radiated from the stars.

2. Nuclear fusion: Process where two atomic nuclei are joined together to form one nucleus.

3. Main Sequence Stars: Stars represented by points that fall within the diagonal band running from lower right to upper left of the Hertzsprung-Russell Diagram; the majority of stars studied fall in this group.

4. Big Bang Theory: Explanation of how the universe was formed that says matter was originally contained in a compact sphere which suddenly exploded.

5. Light Years: Measurement of stellar distances; the distance that light travels in a year, about 9.5 million kilometers.

6. Galaxy: Huge collection of stars, star clusters, dust, and gas held together by gravity.

7. Milky Way: Name of our galaxy. A thick band of stars located in the center of our galaxy.

8. Constellation: Group of stars.

9. Luminosity: A star's absolute or real brightness.

10. Supergiants: Huge stars that are as much as one million times as bright as the sun.

11. Giants: Stars that are remarkable for their large size and which may be as much as 100 times brighter than our sun.

12. Subgiants: Class of stars on the Hertzsprung-Russell diagram ten times brighter than our sun.

13. Hertzsprung-Russell Diagram: System of classifying stars according to their real brightness and temperature.

Word Puzzle (p. 267):

Electromagnetic
Big Bank Theory
Luminosity
Constellation
Milky Way
Hertzsprung-Russell Diagram

Word Puzzle:	T	H	E	B	L	A	C	K	H	O	L	E
	1	2	3	4	5	6	7	8	9	10	11	12

Vocabulary Skills (p. 283): Definitions given below. Sentences will vary.

1. Axis: The imaginary line on which the earth rotates.

2. Satellite: A small object in orbit around a large object; a moon.

3. Asteroids: Small planets between Mars and Jupiter that orbit around the sun.

4. Photosphere: Extremely bright surface layers of the sun.

5. Chromosphere: Lower part of the sun's atmosphere.

6. Corona: Halo-like layer of the sun visible during solar eclipses.

7. Solar Flares: Sudden eruptions of very hot gas appearing as bright spots on the sun.

8. Sunspots: Violent magnetic storms on the surface of the sun that appear as dark spots on the solar surface.

9. Prominences: Giant streamers of hot gases that arch far out into space before they return to the sun's surface.

10. Solar Wind: Tremendous stream of highly charged particles that the sun sends out into space.

11. Magnetic Field: Region near a magnetic object or electrical current in which magnetic forces can be detected.

12. Photosynthesis: Process by which plants use sunlight to produce food.

13. Phases: The changes in the visible fraction of the illuminated surface of the moon or a planet.

14. Meteor: A very small stony or metallic body traveling through space that burns up when it enters the earth's atmosphere.

15. Meteorite: Stony or metallic body traveling through space that does not burn completely when entering the atmosphere and eventually crashes into the earth's surface.

16. Eccentric Orbit: Irregular path of planet around the sun (or another star).

17. Craters: Depressions on the surface of the moon or earth believed to be formed by meteorites hitting the surface.

Maria: Dark regions on the surface of the moon that look like seas.

Hidden Word (p. 284):

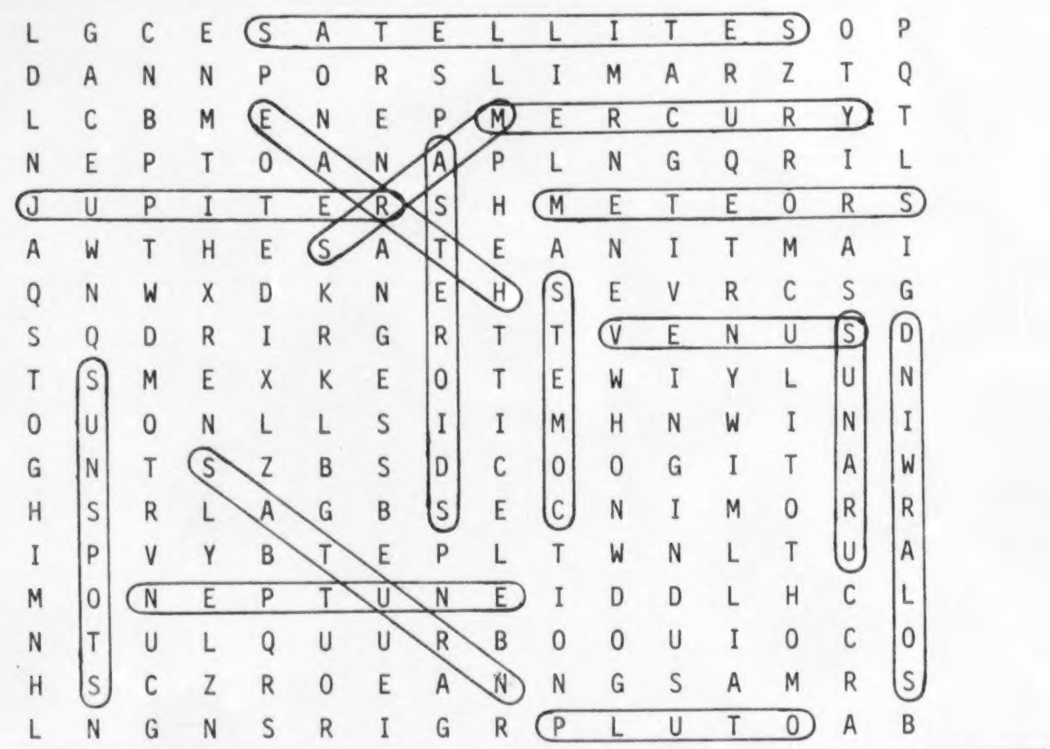
1. Milky Way
2. Satellite
3. Mercury
4. Mars
5. Jupiter
6. Photosphere
7. Prominences
8. Asteroids
9. Saturn
10. Meteor
11. Comet
12. Pluto
13. Galaxy
14. Venus

UNIVERSE

Fill In The Blanks (p. 285):

1. gravity
2. hot gases (hydrogen and helium)
3. hydrogen
4. prominences
5. magnetic storms
6. solar flares
7. earth's magnetic field
8. (a) mirrors (b) solar collectors (c) solar cells
9. the core
10. photosphere

Word Search (p. 286):



L	G	C	E	S	A	T	E	L	L	I	T	E	S	O	P
D	A	N	N	P	O	R	S	L	I	M	A	R	Z	T	Q
L	C	B	M	E	N	E	P	M	E	R	C	U	R	Y	T
N	E	P	T	O	A	N	A	P	L	N	G	Q	R	I	L
J	U	P	I	T	E	R	S	H	M	E	T	E	O	R	S
A	W	T	H	E	S	A	T	E	A	N	I	T	M	A	I
Q	N	W	X	D	K	N	E	H	S	E	V	R	C	S	G
S	Q	D	R	I	R	G	R	T	T	V	E	N	U	S	D
T	S	M	E	X	K	E	O	T	E	W	I	Y	L	U	N
O	U	O	N	L	L	S	I	I	M	H	N	W	I	N	I
G	N	T	S	Z	B	S	D	C	O	O	G	I	T	A	W
H	S	R	L	A	G	B	S	E	C	N	I	M	O	R	R
I	P	V	Y	B	T	E	P	L	T	W	N	L	T	U	A
M	O	N	E	P	T	U	N	E	I	D	D	L	H	C	L
N	T	U	L	Q	U	U	R	B	O	O	U	I	O	C	O
H	S	C	Z	R	O	E	A	N	N	G	S	A	M	R	S
L	N	G	N	S	R	I	G	R	P	L	U	T	O	A	B

Hidden Message (p. 287):

Photosynthesis
Phases
Craters
Magnetosphere
Rilles
Highlands
Axis
Water
Atmosphere

Answer:

The moon is the Earth's satellite.

Matching (p. 288):

1. F, 2. D, 3. L, 4. J, 5. G, 6. I, 7. H, 8. C, 9. K, 10. B,
11. E, 12. A

Name the Planet Described (p. 289):

1. Earth or Mars 2. Mercury 3. Mars 4. Saturn 5. Jupiter 6. Venus
7. Mars 8. Mars 9. Mercury, Venus, Pluto 10. Jupiter.

Matching Gods (p. 289):

1. (g) 2. (d) 3. (b) 4. (e) 5. (i) 6. (f) 7. (c) 8. (a) 9. (h)

Data Chart (p. 290):

Answers to data chart are on p. 359 of this answer booklet.

Missing Plant (p. 291):

1. Earth 2. Venus 3. Jupiter 4. Saturn 5. Neptune 6. Pluto and Mercury

DATA CHART

Use the text and other reference books to gather data for the chart. Fill in as much information as possible.

PLANET	DIAMETER IN MILES	DISTANCE FROM SUN IN MILES	NUMBER OF SATELLITES	ROTATION TIME	NUMBER OF DAYS TO ORBIT SUN	NAME OF SPACE MISSION (IF ANY)	SPECIAL CHARACTERISTICS
MERCURY	3,015	43 Million	0	59 days*	88	Mariner 10	Has an eccentric orbit
VENUS	7,545	67 Million	0	243 days	225	USSR Venera Space Probe	Rotates in clockwise direction Thick atmosphere mostly CO_2.
EARTH	7,000	93 Million	1	24 Hrs.	365.26		Only planet known to have life.
MARS	4,200	141 Million	2	About 24 Hrs.	687	Mariner 10 Viking Landers	The red planet.
JUPITER	86,900	484 Million	14	10 Hrs.	12 Yrs.		Largest planet, great red spot.
SATURN	74,700	887 Million	15	10 Hrs 14 Min*	29 Yrs.	Voyager I	Many rings.
URANUS	31,000	1,780 Million	5*	10 Hrs 49 Min*	84.02* Yrs.	Fly by Voyager II 1981*	**
NEPTUNE	31,000	2,780 Million	2*	15 Hrs*	164.8* Yrs.	Fly by Voyager II 1981*	**
PLUTO	About 3,015	3,670 Million	0*	6.39 days*	248.9* Yrs.	**	Has an eccentric orbit.

* Not found in text material
** Not known

Multiple Choice Questions (p. 311):

1. (b) 2. (d) 3. (a) 4. (d) 5. (d) 6. (d) 7. (a) 8. (d) 9. (d) 10. (a)
11. (c) 12. (a) 13. (b) 14. (d) 15. (b) 16. (c) 17. (c)
18. (a) 19. (d) 20. (c)

True or False Questions (p. 314):

1. F 2. T 3. T 4. F 5. F 6. T 7. T 8. T 9. T 10. F 11. F
12. T 13. T 14. F 15. F

Vocabulary Skills (p. 315): Definitions given below. Sentences will vary.

1. mechanical energy: the result of moving objects such as turning of a wheel.

2. heat energy: the form of energy that causes heat; e.g., warmth from a fire.

3. light energy: the form of energy that lights a room.

4. molecule: the smallest particle of a substance.

5. electrical energy: the result of moving electrons out of their circular paths around the atom so that they move freely in another material.

6. amber: a hard yellowish to brownish transparent fossilized resin.

7. atom: the smallest part of an element.

8. nucleus: the center of an atom.

9. proton: particle in the center of the nucleus that has small positive electric charges.

10. neutron: particle in the center of the nucleus that has no electrical charges.

11. electron: particle circling the nucleus of the atom that has small negative electronic charges.

12. static electricity: build up of positive and negative electrical charges.

13. current electricity: steady flow of free electrons from a negative source to a positive source over a long period of time.

14. conductor: materials that electrons move easily through such as copper, silver, or gold.

15. insulator: materials that do not permit electrons to flow, such as wood or rubber.

16. circuit: a path for current flow.

17. electromagnetic: having to do with magnetism developed by a current of electricity.

18. refraction: bending of a light or energy wave such as radio waves by the atmosphere.

19. medium: material such as water through which energy (for example, sound waves) or force can pass.

20. rarefraction: region of fewer air molecules in sound waves.

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